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TABLE OF CONTENTS

Instruments of Social Progress. President Karl T. Compton 265
Engineers as Leaders. Gilbert E. Doan 275
Ceramic Educators and S. P. E. E. J. L. Carruthers 278
A Word About Students Who Fail. Warren D. Garman 281
Uses of Microfilms in Engineering Education. R. B. Ketchum 284
Delinquency in the American College. Robert B. Rice 286
Scope and Organization of a Sequence of Courses in Structures in Relation to the Civil Engineering Curriculum. Frank Kerekes 299
46th Annual Meeting:
Status of Engineering Degrees. O. M. Leland 322
Impacts of the E. C. P. D. Accrediting on Physics. D. S. Elliott ... 325
Specification of an Applied Geophysicist. J. C. Karcher 330
Recent Developments in Chemical Engineering Education in Europe. E. E. Randolph 333
New Members 345
Committees for 1938–39 347
English Notes 349
T-Square Page 353
Institutions Included in S. P. E. E. Sections 354
Engineers' Council for Professional Development 356
Civil Engineering Page 357
Engineering Economy Page 360
Supplement:
Accredited Undergraduate Engineering Curricula in the United States, October, 1938.

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INSTRUMENTS OF SOCIAL PROGRESS*

By KARL T. COMPTON, *President*
Massachusetts Institute of Technology

It is just cause for satisfaction whenever an important improvement is made in that greatest of all instruments for social progress: education. We therefore heartily congratulate Northeastern University on the significant addition to its educational plant which we today dedicate to the further fulfillment of that vision which came to Dr. Speare forty-two years ago—the vision of a university for employed men.

Dr. Speare has told me of the assistance and encouragement which was given him by my predecessors, President Pritchett and President Maclaurin of M. I. T., during his early efforts to establish this institution. It is therefore a particular privilege for me to take a small part in the continuance of this tradition, by assisting at the exercises today.

It is said in Proverbs, Chapter XXV, second verse, that "It is the glory of God to conceal a thing; but the honour of kings is to search out a matter." This challenging proverb, it seems to me, is appropriate to an occasion such as this, marking the anniversary of a university and the dedication of a new facility to the service of education. In our democracy, the people must accept and share the responsibilities of the government, of the kingship, if you will; and the vigor and growth of their educational enterprises are a measure of their aspiration to the honor of searching out the matter. It cannot be too often reiterated that in a nation of free men the people must promote untrammeled search for understanding as an essential activity in any program of spiritual and social progress.

Since the building we dedicate today is to be devoted largely to engineering and science, I should like to examine these specific professions as instruments of social progress and to emphasize their influence upon the democratic form of social organization, upon the form that we must now more ardently than ever defend and refine in the face of insistent alien doctrines.

To distinguish between science and engineering as instruments of social progress we might say that science seeks to understand nature while engineering seeks to control nature. Implicit in this

* Address at Dedication of New Building at Northeastern University, October 3, 1938.

destination is the economic aspect of engineering, which is illustrated by an old saying that an engineer can do with one dollar what any fool can do with two. These distinctions have been concisely summed up by a distinguished contemporary engineer, Dr. Gano Dunn. "Engineering," says he, "is the art of the economic application of science to social purposes. . . . The scientist . . . shuts his mind as far as possible to all human prejudice and influence of feeling, save only for the divine fire of that imagination which creates the working hypothesis; and he learns how to discern truth and new knowledge in a study of the order of nature. The engineer, by the same intellectual processes as the scientist, applies that new knowledge to social service."

What are some of the social services rendered by the engineer? I need not enumerate the obvious contributions such as the construction or operation of transportation and communication facilities, industrial plants and processes, mines, machines, and buildings, and in general the modification of our material environment. The engineer contributes in these indispensable ways to the public weal, but, to come nearer the fundamentals, he contributes by adapting the rigorous scientific method to economic and social problems. If he is true to his profession he views situations objectively, draws rational conclusions from observed facts, plans his course intelligently in the light of these facts and conclusions and is a safe citizen, therefore, in a self-regulating democratic society.

We see about us today a striking example of the growing efficacy of these peculiar qualifications—the increasing participation of the engineer in management. We are told in a recent study sponsored by the Society for the Promotion of Engineering Education that graduates of engineering or technical colleges are many times more likely to be found in positions of authority than are graduates of other types of colleges or than non-college men. For example, of the 235 college-trained presidents in leading American industries, 151 were trained in engineering or technical colleges, and 84 in colleges of all other types. When we consider the fact that the number of graduates of other types of colleges is many times greater than the number from engineering colleges, these figures are even more striking. They indicate that the probability that a man trained in engineering will become president of an American industrial organization is 10 or 20 times as great as the same probability for a man of different college training. When we consider 54,000 officers of all types in finance, production, engineering, and sales, we find an even stronger predominance of engineering-trained men.

This predominance of engineer-managers is partly the result of the necessity of having complicated technical structures supervised

by technical experts. The more controlling reason, I feel, is to be found in the engineering *mind*—the type of mind Stuart Chase has described as "professional, not commercial; dedicated to building, not to profit-making; that is done with false modesty and has the courage to accept the job of taming the billion wild horses which Watt let loose; that thinks straight and hard; hates waste and confusion, dirt and despair; that never stoops to the shoddy or the adulterated." In other words, the mind that is equipped for leadership in these days of vexing economic and social problems.

Let me stress one further opportunity the engineer has to do superlative social service. Because of his professional status, he stands in an intermediate position today between capital and labor. His training and experience, dealing as he may objectively with both capital and labor, should enable him to resolve the schism between these two groups. No other professional man has an equal opportunity to cut through prejudice and bring about that reciprocal confidence so sorely needed in our industrial society.

Such direct social functions of the engineer are going to be as important in the future as what the engineer may do to conserve and augment our natural resources, to improve our lagging distribution, to lower the cost of adequate minimum housing, and generally to raise our standard of living.

Coming now to science, I think we may say, in elementary terms, that it contributes to our social progress in three major ways: by creating wealth through the capture and efficient utilization of energy; by providing a better understanding of man and his environment; and by adding to the dignity of the human spirit through understanding and achievement.

That energy is wealth and that the wealth level of mankind is determined by the control and use of energy are salient facts too often overlooked. The achievements of the "Golden eras" of history when art, literature, law and philosophy made great advances were possible because people possessed cheap energy provided by slaves or serfs. Then human beings were driven like machines to produce the wealth which enabled the fortunate few to follow intellectual pursuits. In the modern world, science has made possible machines and mechanical power which provide energy equivalent to the output of fifty slaves working full time for each man, woman, and child. It is due to the energy thus made available by science that every person now has, potentially, unrivalled opportunities for cultural pursuits and recreation. It is this energy to which we owe the years free for universal education in our youth, vacations and shortened hours of labor in our middle years, pensions and security in old age.

I need give but one illustration of science's creation of energy

and wealth—the discovery of electro-magnetism by Joseph Henry in America and Michael Faraday in England. Henry gave up his career as an actor to investigate electrical phenomena. At the same time, Faraday at the Royal Institution was demonstrating his scientific discoveries to the Prime Minister, who asked, "What is the use of these things?" Faraday replied, "My Lord, someday you will tax these things." This has come literally true, and besides paying huge taxes, the electrical industry gives employment directly to more than one and three-quarters million people in the United States, and indirectly to probably twice that many more. Taking account of the dependents of these employees, it may be said that approximately ten million inhabitants of our country owe not only their cultural advantages and their standard of living, but their very existence, to the discoveries of those two scientists, supplemented, of course, by the work of a great number of subsequent scientists and engineers.

The enormous energy resource made possible by science is but a minute fraction of the energy available to us; to increase this fraction is one of the fundamental problems and potentialities of science. Every person can be made many thousands of times as wealthy as he is today, but only the scientist, impelled by disinterested curiosity, can find the way. Here, then, is one of the ways by which science may pay astonishing dividends and contribute to economic health; it will do so, not by depleting natural resources but by fresh creation. As one of my colleagues has phrased it, "The world must inevitably reach a state where its wealth will come less from natural resources and increasingly from intelligent resourcefulness." Science is planned, methodical resourcefulness in one of its most productive forms.

But the creation of wealth through the capture and utilization of energy—vitally important though it is for the business of living—is of lesser consequence to man's life than is the philosophical value of science. As it has contributed to a better understanding of man and of his environment, science has done much to enable man to apply its wealth-giving values in ways designed to make life itself a better thing. In this respect, the gradual development —which appears to be reaching culmination in our own times—of the social sciences as a set of disciplines combining the traditional ethical and spiritual outlook of the humanities with the accurate and objective method of the physical sciences is of profound import. From this development, even in spite of the distress and near disaster confronting us today, may be expected amelioration of abstract conditions of life fully as great as the improvement of our concrete conditions of living which the past three or four generations have witnessed.

The ultimate recognition of the truth that man is himself a part of the physical world, and subject to the laws which appear to govern it—the recognition which a fully self-conscious social science must bring in its train—cannot but lead to pronounced changes in many of our ingrained beliefs, and in many of our accustomed institutions. Revision of purpose and of method in the socially scientific application of the energy-wealth supplied by physical science may be foreseen as one result. More rationally planned cities and more realistically conceived elementary school curricula are but two practical outworkings of such a revision. What a city is, why it is, and what it does to those who live in it—these are questions whose answers go far to determine what men's life is worth. Insofar as science contributes toward making the answers as close as possible to the truth as we perceive it, just so far does science contribute toward giving the necessary twentieth century implementation to the classic Aristotelian dictum that "Man is naturally a political animal."

Thus far in speaking of science as it has aided in better understanding of man and his environment, I have talked mainly in terms of the future. This is not to mean that the present contribution of science here is inconsequential, or of less value than that to be had in the future. Quite the contrary. One need no more than cite two examples to show the far-reaching practical and philosophical achievements already made. First consider medicine, and consider the swift marshaling of its forces in such emergencies as we have experienced these past few days (the hurricane). How many lives have been saved for usefulness and worth through the quick application of knowledge, through the availability of sera and anti-toxins, and, more, through the readiness of skilled men, would be difficult to reckon. And if we go farther, and try to estimate the number of effective man-hours of productive labor—mental or physical—thus saved, the difficulty increases. To leave this example, and speak more generally, the extension of the normal life-span, the conquest of pestilential scourges, and development of preventive medicine and of public health security, in which the Commonwealth has had so honorable a part—these are further immediate outworkings of the scientific understanding of man and his environment, outworkings which come home to every one of us. At a very far distance from them stands my second example—that of the astronomer and the astrophysicist, whose study and description of man's environment is done in very different, yet in many ways equally important terminology. The alteration in perspective which has come come about as a result of achievements in this kind of science, bringing gradually into focus our picture of the world and the universe, and of our own place

therein, is a most salutary one, salutary both as it clips the wings of foolish fancy, and as it spreads to full sweep the far more powerful wings of sober fact.

This second contribution of science to social progress, with which we have just now been concerned, merges imperceptibly into the third—the way in which science has added to the dignity of the human spirit through understanding and achievement. Today when whole countries seem willing to sink into the meniality and hoodlumism of the mob, we sorely need this dignity of spirit.

By the effectiveness of its method, science promotes confidence. In spite of opposition and ignorance, the scientific method has won field after field, giving us new comprehension, new respect for mind, greater power over matter and the unknown. Through the moral values of its method, science can raise our ethical standards. Only through disinterested passion for truth can the scientist succeed, and the demonstration of this fact is of superlative importance in a time when truth is twisted, particularly for some doctrines of government. It is perhaps among the greatest of paradoxes that the extension of knowledge which has shown man to be, not the center of creation, occupying an earth which is the center of the universe, but rather only one more form of life on a planet comparatively infinitesimal, should at the same time increase, justly and honestly, his sense of his own dedication to something beyond mere being, and his faith that life as manifested in him possesses worth and significance beyond the measure of the very knowledge which seems at first thought to reduce life to formulæ. Yet so it is. And but a little reflection is necessary to enable us to see why this seeming paradox is no paradox at all. As science has pushed the boundaries of knowledge farther and farther back, and has brought more and more out of the shadow of speculation into the light of objective fact, it has shown life to be infinitely more complex, infinitely more mysterious, far more inextricably involved in environmental, physical, physiological, psychic, and psychological issues. It is no more than natural for the logically trained mind, reasoning coldly by inference and association to conclude that the spiritual, the non-material aspects of life may well also be far more ramified, far more mysterious, than would at first appear. If humility is the mark of faith, then science has augmented the dignity of life by giving faith greater reason than ever for humility.

To carry this concept a bit farther, one may well say that the scientific extension of knowledge of man and his environment is a firm basis in many respects for the enhancement of the dignity of the human spirit. To recur to my pair of examples, the fact that the human intelligence is ready to range so widely as from

grappling with the microscopically invisible virus to measuring the unimaginable interstellar space is in itself cause, not for silly pride, but for honest admission of achievement. Objective reason is the greatest safeguard against mere vaunting egotism, yet it is also the surest way to recognition of simple worth. If we can occasionally stand at a safe distance and look at the odd and defenseless beings which we are, and observe the will which has enabled such puny things to do so much, we are forced to this recognition.

But to claim that recognition as a birthright is not merely dangerous but wrong. Equally wrong would it be to claim for science that honor of being the means alone by which that recognition may be won. Not through science alone, for science alone is well nigh powerless, but through science working in right circumstances, have both these practical attainments and their philosophical consequences been achieved. I cannot conclude remarks on such an occasion as this, with such conditions as now prevail in our world, without asking that you consider what these right circumstances are, and what they necessitate.

Science and engineering have flourished best in the clear daylight of free speech and where initiative and the urge to discover have not been restricted either by complacency or by suppression. If they are to continue as powerful forces for good, these circumstances and these values, common to both science and democracy, must be preserved.

In a brilliant essay on the taming of dangerous government power, in the current *Atlantic Monthly,* Bertrand Russell remarks that "the temper required to make a success of democracy is, in the practical life, exactly what the scientific temper is in the intellectual life; it is a halfway house between skepticism and dogmatism. Truth, it holds, is neither completely attainable nor completely unattainable; it is attainable to a certain degree, and that only with difficulty."

Today when we are compelled to defend democracy as an instrument of social progress we need more than ever to cultivate this scientific temper in our group activities, both industrial and political. We need to be unflinching in the face of facts, unwilling to manipulate truth for the sake of doctrine and political ideology, courageous to accept personal responsibility rather than to take refuge in the unskeptical comfort of the puppet mass.

I can not presume even to suggest where the proper functioning of the scientific temper may lead us. At most, I can only venture to suggest some general principles of government which seem to me to be fundamental in utilizing and preserving the scientific temper.

The first of these is that a degree of centralized government is an essential attribute of decent group life. Without it there is chaos, discord and ineffectiveness. Without it there is no security; and complete freedom from controls does not give liberty but rather the worst of all subjugations, anarchy without protection. But with government comes orderly procedure and directed coöperative effort so that the group becomes greater than the sum of the individuals which compose it. Undoubtedly the increasing complexities of modern life, due largely to technological progress, require a continually increasing degree and quality of group control.

The second principle is, at first glance, the antithesis of the first. It is that wise government involves the minimum of control and supervision consistent with reasonably smooth, coördinated and properly oriented operation. It is an evolutionary principle that, as individuals or groups grow in their ability to accept responsibility, the controls imposed on them are relaxed in order that they may accept and discharge responsibility. In this manner they develop their own powers and increase the contributions which they can make to their social group. This is a basic principle in training young animals and children, in the education of public men and in the functioning of civil organization.

The greatest of all government problems today is to determine the most advantageous balance between these two principles. How much control should be exercised and to what extent should it be centralized? The question arises in business and in government.

Large groups always evolve more slowly than small groups, so it is not strange that governments in many parts of the world today are rapidly moving in the direction of increasing the scope of control and its greater centralization, sometimes even into the hands of one individual. This was the trend of our industrial organizations generations ago. A fair evaluation of this tendency in governments discloses that it has in many cases come about from natural causes, such as insoluble complications resulting from the great war, or the previous relaxing of controls before a perplexed people had developed the power to accept the concomitant responsibilities, or for other reasons. As was the case in overdeveloped industries, the dangers in this movement in governments lie in such factors as present or future mismanagement on a large scale, disregard of the rights of other groups in the confidence and ambition of their present strength, failure to develop enough independent leadership within the group, inefficiency and inability to secure any true evaluation of results or policies because of suppression of criticism.

The dangers confronting the less centralized democratic governments, on the other hand, are likely to be indecision in crises,

inconsistency of policies, inefficiency in operations, continual necessity of compromise between groups. We of democracies, however, believe that in the long run there is strength even in these apparent weaknesses, because they guard against rash actions, they develop the average intelligence and responsibility of the whole population and the whole setting encourages individual development and free enterprise. We find justification for our belief in the record of economic prosperity, in those countries where democracy has been a spontaneous development from within, not imposed from without.

There are very important questions of government on a large scale facing most of the people of the world today. Our brethern in some countries are putting their faith in the highly centralized management of dictatorships and authoritarian states. Our brethren in other countries, and we in America, have put our faith in a form of government definitely designed to serve and not to manage the citizens and to give maximum opportunity for free initiative and free expression. This situation offers a great opportunity to watch the results of the two sharply contrasting theories of government as an experiment on a colossal scale. God grant that our observation of this experiment be not interrupted by any action that will do irreparable damage to all people in both groups.

My final suggestion of a principle of government is the outgrowth of my contacts as a scientist. Experience has amply demonstrated a fact that, at first sight, seems surprising. It is that the most significant technological advances have not come out of direct efforts to make them, however well organized, but as unexpected by-products of scientific work undertaken for quite other objectives—usually for the satisfaction of scientific curiosity. Organized, directed effort is very effective in perfecting the details of a product or its production, but not in its initial discovery. This contrast is greater the more epoch-making is the new discovery.

The logical reason for this is not hard to understand. Really epoch-making discoveries are relatively unpredictable in advance. The practical solution to a difficult problem may come from any one of a multitude of directions. Really new ideas do not come to order, and are not pulled out of a hat, and who can tell in whose brain they will germinate. If an industrial research laboratory had been established a century ago to improve lamps, it would have investigated inflammable oils and gases, wicks, chimneys and refractories. Not conceivably would it have paid attention to the leakage of electric charges through the air or to the behavior of magnets, wires, acids and frogs' legs. Yet from these actually came the modern lighting devices.

I believe that the same logical and psychological principles operate in the field of government generally. A highly centralized and organized form of control may be very effective in performing the specific functions assigned to it in the manner stipulated by headquarters, but it is not a favorable type of organization in which to take advantage of the potential genius inherent in the group which, if given opportunity, may produce better leadership, and develop more advantageous objectives and effective operations.

So I believe that experience, logic and human psychology all support the view that that type of government is most likely to be successful in the long run which directs and inspires but does not too rigidly control, which offers large opportunity for initiative and for criticism, which has faith in the mass judgment of an intelligent group and in the genius which may appear in unexpected quarters—all of which means that I have faith in the great social invention, democracy, and that I feel that the professions represented in the building we dedicate today are instruments of social progress that must be allowed to flourish without restriction if democracy is to endure, if we as a people are to attain the honor of searching out the matter.

ENGINEERS AS LEADERS

By GILBERT E. DOAN

Professor of Metallurgical Engineering, Lehigh University

A good deal has been written and spoken about broadening the engineers' curriculum without always making clear the objective behind this trend. It can, however, be stated in one sentence: To enable the student to extend the realistic approach of the engineer to the great majority of his future problems, that is, to those which border on or lie outside of engineering.

Almost all of us would agree that this realistic approach to social and individual problems is desirable. There is, however, a class which continually mistrusts the engineering approach and that is the one which includes the lawyers and economists. They are, as Professor Thurman Arnold of Yale calls them, the "high priests" of our present social cult, the one who argue in vague terms about abstract ideals and "isms" instead of coming to grips with the obvious needs of our country to-day to improve conditions on the farm, in the factory, and in the home. This group criticizes the engineer as one who seeks to "rigidify" any system or problem which he examines. We exclude all human and emotional factors from our calculations in social problems, they say, and strive to fit the situation into a concrete equation by excluding all non-quantitative factors, and then proceed to solve this equation and apply the solution to the group concerned as if they were guinea pigs.

The economists and lawyers do not realize that they themselves attempt to rigidify the recent past into a set of convenient generalizations, called economic and legal "principles," likewise rejecting any forces which do not fit into their theories, and then attempt to judge the present and predict the future on the basis of these selected and rigidified theories. The reason so many economists have been wrong in their predictions is that they too love to simplify their pictures by neglecting those facts that do not fit, such as "politics," and technological developments. That is why their predictions during the early years of the depression were so universally wrong. Most of them could, for example, have proved to you that Henry Ford was wrong in his early plans for wage raises. At about the same time Woodrow Wilson "proved" that the automobile would split democratic America into two social classes:

those who could afford cars and those who would have to take their dust.

Their mistakes do not excuse ours, however, and if we hope for the day when the engineering approach, that is the factual and realistic approach, shall extend to the larger and more complex problems before the country, then we must be prepared to turn out effectively prepared graduates who, in addition to the engineering habit of mind, shall have an awakened consciousness of the non-material forces which operate in their world. When an engineer, retained perhaps in a law case, listens to an impassioned plea for liberty by a lawyer or politician who is bent on greater liberties for a small group at the cost of liberty to millions of people, the engineer who is listening must be able to feel sure that he knows what liberty is, and to distinguish that part of the plea which is sound reasoning from the part which is superstition and drama. *He must not lose his effectiveness in the case when such values as liberty, drama, and superstition enter it.*

Stuart Chase may show stupendous wastage of national assets by soil erosion such as any engineer left to his own judgment would check immediately. But when soil conservation is labelled either "communism" or "bureaucracy," the engineer is scared off as by threat of a mysterious disease. Superstition paralyzes his rational action. Here again the engineer looses effectiveness as a social force at a time when his influence is most needed. Even if the job could be done free by using unemployed labor which had to be supported anyway, he would not feel sure of his program. In brief, when engineers are drawn into broad problems as they are to-day and will be increasingly, they must have an effective background of social philosophy or they will be relegated to the side lines to listen with awe and wonderment to the decisions of their "superior" colleagues.

This is the reason for the inclusion at M. I. T., Carnegie Tech., and California Tech. of required studies in history, philosophy, the social sciences, and literature. If the engineering approach to national problems is to fulfill its obvious mission in America, it must receive from the schools men firmly grounded both in science and the humanities, men with a balanced foundation and a broad and flexible approach to industrial problems.

Both experimental psychology and actual experience show that engineering training *associated* with the study of humanistic problems makes possible this balanced foundation, while the study of technologies for four years in a social vacuum followed by a sudden impact with the world of affairs results in an engineer who is timid and unsure whenever a large-scale project is discussed.

As engineer educators, we can well afford space in our curricula

for this bolstering of the humanitarian studies. The increasing vogue of post-graduate study in engineering, both at the university and in industry, is providing ample room for the more specialized technologies. As engineers, we can, however, ill afford to discourage and stunt the extension of the engineering method into the broader problems of to-day by turning out graduates who are unprepared to make this extension when it is called for. *The increasing domination of the engineering mind in the world's affairs is the manifest destiny of our chosen field if we but give our students the proper breadth of foundation to measure up to it.* Such a program should bring us an increase in numbers of high-grade students, more support both by endowment and by industrial influence, and higher respect in the general academic mind.

Our technical civilization will be led by the technically-ignorant lawyers and economists only so long as our engineers are not qualified to lead.

CERAMIC EDUCATORS AND S. P. E. E.

By JOHN L. CARRUTHERS

Professor of Ceramic Engineering, The Ohio State University

It seems to be a part of the philosophy of American life to organize and hold meetings, read papers, and discuss problems of mutual interest. This statement is well exemplified here in the meetings of the American Ceramic Society and the Ceramic Educators. In addition, it is often necessary to organize to protect one's interests, especially when many other people think that they know best how to regulate your welfare, conduct your business, and so on, and which one might say was the basis for the founding of this organization and others.

An analysis of conditions will indicate that as educators, we have problems which can best be met by coöperation along three lines, namely, membership in the American Ceramic Society, the Association of Ceramic Educators, and the Society for Promotion of Engineering Education. We attend the meetings of the Ceramic Society (or read its papers) in order to give and receive of the advances in ceramic science and art, so that we may in turn interpret the findings and pass them on to our students. As teachers of ceramic subjects, we are here in this meeting to discuss our common problems in ceramic education. However, if we, especially those dealing with ceramic engineering education, are to receive full benefits of the advances made in engineering education, it would be necessary that we coöperate in the work of S. P. E. E.

Briefly, I want to state my reasons why I believe every ceramic engineering educator should not only belong to S. P. E. E., but also should take part in its activities.

1. With the developments of the last few years in the Engineers' Council for Professional Development, it is necessary for ceramic engineers and ceramic engineering educators to be a part of or to be affiliated with organizations that are a part of E. C. P. D. in order that we can be considered as the definite profession to which we know we belong.

2. Since E. C. P. D. has recognized ceramic engineering, it should be our policy to capitalize on that recognition and further our own interests.

3. S. P. E. E. is the one organization given over entirely to the problems of engineering education. Certainly we can benefit from

the experiences of others in engineering education and should also be contributors.

4. There are various ways for coöperative effort in S. P. E. E., such as joint meetings with other divisions with whom we have common interests in the search for improved methods of teaching.

About the only argument that might be expressed against membership in S. P. E. E. is that it is just another organization to join, with meetings to attend and dues to pay. However, other engineering educators have the same problem, *i.e.* of belonging to their professional societies and S. P. E. E. and attending meetings of both organizations. Their experiences would indicate that they find it quite desirable to actively take part in both, and undoubtedly we also find it desirable.

It is true that in the Association of Ceramic Educators we can do some of the things that are ordinarily done by other engineering teachers at S. P. E. E. meetings. However, unless we expand our activities at the time of the American Ceramic Society meeting to at least two full half-day sessions, we really do not have the time to fully discuss and consider the problems that do come, or should come, before us. All of us attending the American Ceramic Society meetings generally have several things to do at this time and the amount of consideration that we can give to engineering education problems must necessarily be limited. Therefore, it would seem desirable to have the time for the discussion of our problems that would be obtained at an S. P. E. E. meeting.

Also, while the membership in the Ceramic Educational Council is made up largely of ceramic engineering educators, yet we must remember that there are teachers of ceramic art and ceramic technology in the group, and consequently we must also give consideration and time to their problems. To me, it would seem that the meetings of the Association of Ceramic Educators could best be devoted to what might be called ordinarily answered through committee work, questionnaires, and reports. It is my opinion, therefore, that we not only need this Association, but that the engineering educators in ceramics also need S. P. E. E. and should take part in its activities and meetings when possible because of the time available for discussions, the benefits to be obtained from coöperation with other engineering educators, and other reasons previously given.

Shall the ceramic committee of S. P. E. E. plan to hold sessions at the annual S. P. E. E. meetings? My answer to this question is yes, with certain limitations. S. P. E. E. meetings are held in such widely spread places that in some years it would hardly be possible to muster enough members to hold a session. Yet if we followed the lead of other engineering educators we might always

be able to have an annual meeting. Certainly in years when the meeting place is centrally located should be the occasion for a good full session.

At the same time, we should also be planning joint sessions with other divisions in order to obtain full benefits from the S. P. E. E. meetings. Many of our teaching problems are in subjects that are common to curricula in Mining, Metallurgy, Chemical, and Mechanical Engineering and really worthwhile programs could be developed. Various subjects in which we have a common interest and in which programs could be planned are heat transfer, flow of fluids crushing, grinding, screening, benefication of minerals, filtration, mixing, combustion, fuels, drying, drier, furnace and plant design, mining, dust hazards, and conveying of materials. It is true that many of these subjects are perhaps taught outside of our ceramic departments in some schools, yet they are all essentially as much ceramic engineering subjects as they are subjects in other fields and we should be concerned with how and what is taught, even if we are not actually teaching such subjects.

The question as to the place for the publication of papers on ceramic education was raised because of the restriction that the American Ceramic Society by-laws place on the activities of classes. Since the Association has petitioned to be recognized as a class in the Society,* it was thought that the rule in regard to programs might prevent us from presenting papers at our sessions and having them printed in the publications of the Society. The thought in mind was, that if such was the case, then they could be presented to S. P. E. E. as a contribution from the Ceramics Committee. Also, it might be quite desirable to have our papers on educational problems printed in the *S. P. E. E. Journal* in order to definitely strengthen and fix our place in the scheme of engineering education.

In closing, it seems to me that the benefits that can be obtained from membership in S. P. E. E. with active participation in its affairs are so great, that from the standpoint of ceramic engineering as a profession and as engineering educators, we cannot afford to miss them.

* The Association of Ceramic Educators is now a class in the American Ceramic Society and is known as the Ceramic Educational Council.

Note.—This paper was prepared as an answer to several questions which had been presented to the membership of the Association of Ceramic Educators. This paper has just been received, and is mimeographed and forwarded to you for your information. A copy is also being forwarded to S. P. E. E., as was voted at the last meeting of the Council.

A WORD ABOUT STUDENTS WHO FAIL

By WARREN D. GARMAN

Assistant Professor of Mechanical Engineering, Bucknell University

The college teacher cannot help but be impressed with the fact that he meets his students during a most critical time of their lives, for it might be said that all the experiences and tragedies of a lifetime are compressed into the short space of a college career. As freshmen, the students enter a new life; one which must terminate in only a few years, and in that brief interval of time they must either succeed in a major undertaking or they must fail. Graduation day, four years hence, stands out as the success of life itself, and if that goal cannot be attained the gloom of complete failure is almost certain to take possession of those who fall short. Such an experience may have a very destructive effect on the characters of the unfortunate students, and it might seriously retard, or even prevent, their ultimate adjustment to the conditions in which they must live. The detrimental effects of this disappointment might be lessened if the students could realize some measure of success along with it, and at the same time be brought to see that very often such experiences are necessary to force men into their proper niches in life.

We, as individuals, have the desire to help an associate who is in trouble, but, as we ponder over these matters, we find ourselves wondering whether the engineering school should concern itself with the plight of the men who will not become graduate engineers. The fundamental purpose of the school is to prepare young men to take their places in the engineering profession; a mission which is growing more and more important as the qualifications of the engineer are becoming more exacting. The engineering profession is already trying to guide the youth in his high school days with the hope that only those who are fitted to be engineers will follow that course in college. This procedure will undoubtedly raise the standard of the engineering students as a whole, and it will also cut down the number of failures in college, thereby relieving, to a degree, the situation which provoked the present article. However, the success of the engineering profession and of society in general depends not only upon the type of engineers that is graduated from the schools, but also, to a large extent, upon the tradesmen who carry out the ideas which the engineer has conceived. It is reason-

able to think that many of the men who start on a college course and who are unable to finish it have the qualifications which these workers should have. Those of this class who manage to find their way into the trades often do so after a great waste of time and energy, and after many discouraging experiences in unsuitable kinds of work. Some guidance and a little encouragement at the right time might do much to alleviate these conditions. Evidently, the engineering school can render a valuable service to society by judiciously handling these so-called failures.

In order to improve the morale of the students who, for honorable reasons, must leave college before they have completed the prescribed course, a certificate could be given each of them. The certificate would bear a list of the work that had been satisfactorily completed by the particular student to whom it referred. Since this manner of recognizing the accomplishments of students has been used by certain trade schools, it is not entirely new even though it may not have been used in the colleges. In the matter of landing a job, such a certificate probably would not have any more influence than the college diploma has in this respect, but it would be a means of assuring the students that the time they spent in college had not been wholly wasted. Furthermore, it would be proof that their efforts had gained immediate recognition. Surely, the recipients of these certificates would leave college in a better frame of mind than under the present system of dismissal. This procedure would improve their ability to recover from the disappointment they had suffered, and they would be in a better position to make the new start in life.

Much additional good could be accomplished if the qualified men could be encouraged to enter trade schools or start on an apprenticeship in the trades. The advisability of encouraging anyone to enter the trades can be questioned, in view of the fact that the present production methods makes more use of so-called specialists, or handy-men, than of versatile mechanics. However, we must remember that the demand for mechanics becomes greater as the methods and machinery of industry become more complicated. The service department of any one large industry employs as many high class craftsmen as were employed by several independent shops of earlier days, and the new industries add materially to the number of such departments. Moreover, as the demands made of the engineer are raised, the gap between that profession and the trades is made wider. This gap could well be filled with men who have had some college training. Then too, outside of the production plants, as well as within them, the qualifications of the mechanic are on the upward trend. For instance, in the days of the 'tin lizzie' almost any tinkerer could repair an automobile, but today

the mechanic has a real job on his hands when he tackles the repairing of one of the more powerful cars with its many refinements, numerous accessories, and automatic features. As another example, contrast the home heating systems of a few years ago with the thermostatically controlled, stoker fired, or oil burner plants of today. Very few owners attempt to keep these systems in adjustment because of the complicated mechanisms involved in their control. The installation and maintenance of these, and of many more commonplace fixtures of our homes, require the services of men who can read and understand drawings, diagrams, and directions which may involve several branches of science. It appears that the demand for mechanics of a superior type will keep pace with the requirement for other workmen, and therefore, it is not inadvisable to encourage young men to enter the trades.

USES OF MICROFILMS IN ENGINEERING EDUCATION

By R. B. KETCHUM

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Experienced teachers of subjects in engineering have long felt the need of some method of bridging the gap between text books and real up-to-date engineering practice. Text books properly give general descriptions of methods and picture drawings to illustrate what is described. Reproductions of actual working drawings are seldom practical in text books. When the student goes on the job where he is expected to turn out some shop drawings fully dimensioned or to do other similar detailed work, he finds himself woefully lacking in knowledge of the detailed information he needs and his notes and text books are usually far out of date and too general to be of much use. The use of the microfilm service now available offers a practical help in this connection, and engineering education is behind in the use of this facility which has almost unlimited possibilities for future use. For three years the "Bibliofilm" service has been in use in the Library of the U. S. Department of Agriculture, and this with the "Docufilm" service as described in the May issue of *American Library Association* and the January, 1938 issue of *Applied Physics*, are rapidly expanding in their new applications. Microfilm reading machines which also may be used for projection and printing are available at reasonable prices. With these facilities a student could take away with him, at a small expense, a library of valuable reproductions of actual up-to-date working drawings, tables and diagrams to supplement each course. This library could be expanded after the student graduates, to conform to the special line of work where he is employed. If the student takes, say twenty technical engineering courses during his junior and senior years, and if he gets a fifty exposure film in each course, he will have, in all, a library of selected material of a thousand drawings, tables and diagrams to take with him at the time of graduation for a total expense of about twenty dollars. If this material be carefully selected by the teacher, and kept up to date it will be far more valuable than the student's notes and text books.

Other uses of these facilities are rapidly developing and the engineering student should be required to begin using them in order to develop his imagination in this direction. For example, where

there are fire hazards the preservation of valuable office records can be assumed by use of the microfilm.

The preservation of valuable records of important engineering construction during the progress of construction of new structures or modification of old structures; the use of color microfilms in aesthetic studies in connection with existing or proposed structures; the use of the microfilm in research work to bring material to the researcher from distant libraries where information is centralized—all these and many other applications will be used.

We suggest that government agencies may properly cooperate with technical societies, technical schools and industries to centralize technical information where it may be classified and made readily available for distribution to technical schools.

DELINQUENCY IN THE AMERICAN COLLEGE*

By ROBERT B. RICE

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Introduction

For some years the colleges and universities in this country have been confronted with the problem of what to do regarding cases of cheating and other unethical or unsocial practices of students. Some of our institutions have studied the problem rather carefully and to all outward appearances at least have solved it to some degree. Others have done little in the hopes that time will be the cure-all.

Studies in the past have shown that irregularities on the part of students in examinations and tests represent but a small per cent of the cases which may be classified as delinquencies. It is not the purpose of this paper to disclose what has been done but rather to present the situation in hopes that the average educator will better appreciate the situation and lend to its correction. To the writer it seems impossible that there can be any one system which will be inclusive enough to meet all conditions in all phases of education in all parts of the country; however, there are certain fundamentals that each individual connected with the educational process should be familiar with. After all, a teacher in an engineering school is expected to be, not only a specialist in his field of engineering, but, an expert in education as well, and must keep in mind, foremost above other values, the fact that our schools are trying to build character and honor.

I

It has been stated that crime in the United States represents an expenditure of nearly twenty billion dollars a year most of this being spent on institutions to care for delinquents. Reviewing the economic status of our country at this instant, one is led to believe that crime is our nation's largest industry.

At least to an educator, it indicates clearly the need of concerted effort on the part of all intelligent individuals in all walks

* Presented at the Spring Meeting of the Southeastern Section, S. P. E. E., at Clemson College, S. C., April 22, 1938.

of life and in every phase of society to turn the tide of crime in the direction of racial improvement. The hypothesis that this is possible is based on the fact that man can if he will, control the conditions of his living, as well as the forces and resources of nature, to breed a more ethical as well as intelligent race. More specifically, this could be accomplished through better control of the environment and training of the individual not only in childhood but throughout his entire life. That there are environmental factors often beyond the scope of conscious control and sometimes appearing to rule man's behavior is suggested, not with the idea of sanctioning misdemeanors, but rather, placing them on a level with many other scientific values we have to deal with in our search for truth. It is well to keep in mind that these factors influence all, consciously or otherwise, regardless of their walk in life, social position, advantages or disadvantages. It is true that some will be affected more than others but the resistance of all must be built up to a point where the disastrous results will be minimized.

This resistance should be particularly strong at the college level principally because of the tremendous influence those who attend our institutions of higher learning have upon our social order. The more advanced their education, the more this influence will be felt, at first probably by the parental associates of the individual and then by every phase of society with which he may come in contact. From all available information it appears that our colleges and universities are creating a more dominant group who, because of their education and influence on society, make it imperative that all phases of delinquency or any other similar and undesirable emotional factors be properly met and coped with at the level of higher education. That it is a difficult problem goes without saying for most educators will agree that the misdemeanors apprehended and brought to trial do not in any way represent the sum total of all delinquencies. In fact it would appear that only those individuals of normal or sub-normal intelligence, as we now measure it, are the ones who are caught. In many instances because of the slyness, cuteness, cleverness, astuteness or superior intelligence of the offender he is never apprehended with the result that the individual goes through life leaving behind him a wake of social destruction.

A recent survey of the crime situation in New York City, with respect to youth, would indicate that groups of delinquents have perpetrated crimes over a period of several years, including hundreds of robberies and hold-ups, before being caught. This leads us to believe that there are many who never get caught, especially if we consider those who acquire vast wealth at the expense of society while apparently they violate none of our written laws.

How many times does a young man enter college with these perverted qualities so thoroughly and keenly bred into his being that it becomes almost impossible to catch him in a misdemeanor. And, when he is apprehended his case is treated not with the idea of correction, but with the idea of forfeit, he is expelled or given a lecture on right and wrong. He has gambled and lost. If he had won he might have gone on reaping a reward of pseudo-satisfaction, regardless of the final outcome, encouraging future crimes and building up a philosophy of wrong-doing which would in turn influence and permeate a vast portion of our society.

II

The term "Delinquency" is defined by Webster as:*

> neglect of, or failure in, duty.

This would imply implicit understanding of "duty" in all of its phases. A more understandable definition by Healy states that:†

> Delinquency is anti-social behavior or an act forbidden by law.

Where the first definition would suggest almost universal proportions the second is more limiting and applicable to a particular society or social group and implies that the law makes an act a crime rather than the actual deed. Neither of these definitions, while academically correct, seem to fit the situation as we meet it in the fields of education.

Reviewing State laws we find in some states the term delinquency is interpreted to mean a crime committed by a juvenile of eighteen years or younger. In others it is interpreted to include all persons up to twenty-one years of age. California makes a distinction with regard to age as follows:‡

> A child is a person under fourteen years of age; "a young person" between fourteen and sixteen years; a "juvenile-adult" between sixteen and twenty-one years; and all others are considered adults.

An attempt is made to handle each of these groups in a special court in nearly every state, although some states combine the juvenile-adult and adult courts in one.

Cyril Burt¶ gives, perhaps, the clearest picture of the general conception of the term delinquency as we apply it to the college student:

* Websters: Standard Dictionary.
† Healy: "Individual Delinquent."
‡ California Bureau of Juvenile Research.
¶ Cyril Burt: "The Young Delinquent."

An offense committed, or such breaches of the law as would be punishable in an adult by penal servitude or imprisonment—stealing, burglary, damage, common assault, soliciting, lying and sexual impropriety; to this list must also be added certain other misdeeds which none but a child can commit.

While legally a college student may be punished by the law as an adult became of his age, due to the fact that the college tends to protect the student from the law, in many cases, does not temper the fact that crimes committed in a college and not prosecuted by due process of law constitute delinquencies. In this light, it is evidently the full duty of the administration and teaching staff, in assuming their responsibility toward society as well as the student, to administer this responsibility in a manner reflecting the best practices of society without unduly prolonging the infancy of these students.

III

It is obvious that delinquency is in most parts a problem of degree of social seriousness of the act, the criterion being the need of some official action. The Whittier grading scale for Juvenile offenses is a scale developed on this hypothesis. It is a numerical scale from one to ten with truancy indexed as one, serious theft graded five, and murder ten. The numbers are additive on a record in the form of demerits. This system of recording tends to show an ascendency of delinquency, the tendency being to go from bad to worse, especially if the individual is not apprehended.

The whole scale of degeneracy from child to adult and from truancy to murder is depicted rather notably by Booth * who shows clearly the difference between the casual and the habitual offender. The fact that a casual offender may become an habitual offender is of utmost importance to higher education in its handling of the problem and suggests the use of methods and techniques for correction rather than for discipline. Dr. Thomas Arkle Clark once said on the subject: †

The purpose I have kept before me in whatever I have recommended is, first of all, to correct the offender, to turn him in the right direction, to make it less likely that he will offend in this regard again.

Evidence would indicate that an offender who is corrected is less liable, in most cases, to offend again, although with the habitual delinquent this program has had little success in the past.

* Booth: "Stealing Through Life."
† Clark: "Discipline and the Derelict."

IV

A study of delinquency in terms of the situation out of which it arises would indicate that its causes are environmental. A study of the geographic distribution of juvenile delinquents in the city of Chicago ‡ indicates very clearly that slums, poor housing conditions, and areas without playgrounds were most conducive to crime. Other basic environmental factors influencing the delinquency and reflecting home life are: §

1. Family life.
   - *a.* Death of parents.
   - *b.* Divorce of parents.
   - *c.* Separation of parents.
   - *d.* Desertion.
2. Alcoholism of parents.
   - *a.* Mother or father.
   - *b.* Both.
3. Narcotics.
4. Poverty.
   - *a.* Lack of proper food.
   - *b.* Lack of proper clothing.
   - *c.* Lack of proper shelter.

Any one of these factors would tend to cause a child to revert to instinctive traits of self-preservation even to the extent of law breaking.

Most colleges have eliminated the foregoing elements at least as a primary or immediate cause of trouble. Some have, however, substituted other factors which are not felt at a lower level of education. These factors, peculiar to the college, should be eliminated or controlled in a manner which will above all cure the offender as well as punish him.

In view of the attempt on the part of colleges to create a desirable environment through the development of good living conditions and the elimination of family influence, that a case of delinquency could exist might indicate a lack of proper integration on the part of the individual student. This tendency toward disintegration is caused probably by conflicts resulting from his struggling in a new environment with a mental state suggesting lack of understanding of the word "success," indefinite aims, and multiplicity of goals. In this instance might not the college itself become better identified with unity of purpose even to the extent of sacrificing some of its more specialized work? Along this line it has been suggested by some that engineering education should

‡ Shaw: "Delinquency Areas."
§ Davis and Barnes: "Introduction to Sociology."

not be taught merely from the economic angle of earning a living, but more from the humanitarian and perhaps social angle.

It is, definitely, the task of the college to assist in the orientation of the youth of our country. Society today is over-burdened with men who, through educational waste, are poorly suited to their work. The college should carefully measure the faculties and aptitudes of its students with the idea of vocational analysis and in every case be concerned with the possibility of improving these individuals along a line which will bring true satisfaction and encouragement. At present many college courses contain a vast quantity of preliminary training which tends to discourage rather than encourage the students.

One of the most disconcerting instances in this connection with which higher education has to contend is the case of the child who was "dedicated at birth" to some particular vocation. Throughout his life he has had this hallucination superimposed upon his being. His efforts toward adjustment, instead of being directed visibly outward are directed inward, making him a case very difficult to analyze because he has spent so many years concealing his emotions from the loving parents who are so anxious to dictate his career toward success. He feels an obligation toward these loving parents: "to do or die." Death being undesirable to himself and painful to his parents he sets out "to do" at all cost. *If his abilities lie in other channels the cost is liable to be very high.* He may sacrifice all sense of social values in the interests of filial piety. He may and often does stoop to the lowest level of cheating in order to satisfy his parental obsession. What he learns he may not long remember but how he does it will linger forever as a dominant factor in his emotional make-up. That parents still harbor remnants of magic and superstition with regard to the vocation of their children is well illustrated * in the case of the mother who read continuously during gestation in order to make her child a scholar. Other factors in the home being desirable or normal the child's inhibitions might not reach any dangerous proportions until he reached the educational level of college, in which instances his would become a serious case.

V

A recent report on the status of crime in this country indicates that while no one knows the true extent, it is a dominant and dangerous factor. It has been shown that there were eight times as many robberies in New York City in one years as in England, Wales, and Scotland for a similar period. Chicago had five times as many murders in one year as London, a city with three times the

* Hollingworth: "Vocational Psychology and Career Analysis."

population. It is suggested by some that laxity on the part of our educational institutions helps to perpetuate crime through lack of apprehension by the school. On the other hand it is reported that the perpetrator of only one out of ten major crimes committed in this country is apprehended and punished and one out of twenty in the case of all crimes. One authority estimates that two per cent of the population of this country is guilty of some criminal act.

If this is the situation in the country at large it is to be expected that many cases in the college will go unheeded. However, this knowledge will give stimulus to the effort of the educator in his attempts to curb delinquencies and to insist that every case be properly handled and not made a sporting proposition. Chief Justice Taft is quoted as saying: *

> The trial of a criminal seems like a game of chance with all the chances in favor of the criminal, and if he escapes, he seems to have the sympathy of the sporting public.

While this situation is often true in our colleges through the perverted philosophy that a crime is not a crime unless the perpetrator is caught, it is equally so as the result of the dramatic exposé practiced by some teachers.

We sometimes think of higher education as being based upon the theory of selection. It is apparent that, while the million students now engaged in study in our colleges and universities may be high in average intelligence, they represent such a cross-section of cultural background that some of them are bound to be victims of environmental factors of a nature encouraging delinquency. This is inevitably true when selection is based purely on good grades determined by poor measurement methods. Environmental factors, other than those discussed earlier, influence an individual at almost any age level but especially so at the college level. It is often said and honestly, that the youth gets his real cultural training during those first few years he is away from home and his family influence. This places a responsibility upon the college and necessitates the extension of its influence on the young man outside of the class-room to the extent of creating and maintaining a healthy environment for all of his activities in this educational melting-pot. This does not necessarily mean that an institution located in the heart of a densely populated area where crime and vice are present in large proportion is doomed to failure because of its inability to wipe out slums. It does mean, however, that its problem will be momentous, taxing every faculty, ability, and power of the organization in its attempt to keep the situation normal. Neither does it mean that the college, to meet these requirements, must main-

* Report American Bar Association—Vol. XLVIII.

tain necessarily a "country club" campus or create an atmosphere of austerity to worldly things and expect that this environmental factor alone will be the cure-all.

Nor through a system of seclusion and selection of clientel, from what they term "the best families," can all of the conditions be met. We have but to look at a case recorded in the annals of one of our foremost eastern universities (of the latter type). During the past year a prominent athlete of high scholastic standing was apprehended in connection with the stealing of several thousand dollars worth of valuables from the rooms of his associates. The evidence in the case would indicate that he had not been guilty of any delinquency before entering college, but, coming from a poor family and associating with sons of wealth in the role of a football hero he was tempted to steal in order to keep up with his associates and do the things they did, and which required money. His first success in stealing, as he was not apprehended for nearly a year, led to further ventures until he was caught.

Another case of somewhat dissimilar nature but pointing to the hidden social hazards of our modern college was perpetrated in an eastern college of high standing, good traditions and situated far away from a center of population. It was found that the sons of several very prominent and wealthy families had contracted, during the academic year, the drug habit. An associate had initiated them into the use of a habit-forming narcotic at an occasion when time was heavy on their hands and the element of experimentation was present.

It is not necessary to go into the results or the outcomes of either of these cases to show that immediate environmental factors are all-inclusive and should demand the intelligent attention of the administration. This should be augmented by the faculty in their attempt to incite interests that will be lasting and which will be with the young during those seemingly idle moments.

VI

The afore-mentioned cases represent examples of the type of delinquency with which the modern college has to contend. A further study of the subject suggests listing, first, the delinquencies encountered at the pre-college level, and secondly, the same for the collge level.

A classification of juvenile delinquencies as given by Burt:*

* Cyril Burt: "The Young Delinquent."

TABLE I

CLASSIFIED LIST OF JUVENILE OFFENSES

1. SEX
   - *a.* Offenses with opposite sex
     1. Of similar age and willing (including soliciting)
     2. Of younger age or unwilling (assault)
   - *b.* Perversions
     1. Offenses with same sex
     2. Masturbation (excessive)
     3. Indecent exposure
   - *c.* Obscenity (excessive, including "corrupting others" by talk)

2. ANGER
   - *a.* Bodily violence to persons
     1. Murder
     2. Wounding
     3. Violence without weapons; fighting, blows (excessive)
     4. Cruelty to children or animals (with bodily injury)
   - *b.* Angry reactions without violence
     1. Bad temper (excessive)
     2. Incorrigibility, beyond control
     3. False and dangerous accusations
     4. Insult, and other forms of mental annoyance
     5. Cruelty to children or animals (without bodily injury)
   - *c.* Violence to property
     1. Malicious damage or destruction
     2. Mischievous damage or destruction
     3. Damage by fire

3. ACQUISITIVENESS
   - *a.* Stealing
   - *b.* Burglary
   - *c.* Begging
   - *d.* Swindling and forging

4. WANDERING
   - *a.* Truancy from school (persistent)
   - *b.* Truancy from home (persistent)
   - *c.* Sleeping away from home
   - *d.* Running away (with intent to remain away)

5. GRIEF
   - *a.* Attempted suicide
   - *b.* Threatened suicide (persistent)

6. SECRETIVENESS
   - *a.* Lying (persistent or extravagant; and excluding the mere concealment of other delinquencies)

In the case of the college it might be more desirable to analyze the subject in a little different manner with the idea of looking for the immediate or sub-conscious cause of the offense. With respect to frequency the list of delinquencies would have the following general order:

TABLE II

LIST OF DELINQUENCIES WITH RESPECT TO FREQUENCY

1. LOAFING
   - *a.* Failure to attend classes
   - *b.* Failure to do required work
2. DISRESPECT FOR RULES AND TRADITIONS
   - *a.* Open disrespect
   - *b.* Secret disrespect
   - *c.* Hazing
3. LACK OF SELF CONTROL
   - *a.* Use of profane language
   - *b.* Incorrigibility
   - *c.* Use of insulting language
   - *d.* Inconsideration of others
   - *e.* Exerting a demoralizing influence
   - *f.* Fighting
   - *g.* Inciting mass-demonstrations
4. DESTRUCTION OF PROPERTY
   - *a.* On the campus
   - *b.* Off the campus
5. GAMBLING
6. ALCOHOLISM
   - *a.* Excessive use by individuals
   - *b.* By influencing others
7. CHEATING
   - *a.* Cribbing in examinations
   - *b.* Copying other student's work
   - *c.* Copying work and submitting as own
   - *d.* Falsifying records
8. LYING
   - *a.* General unreliability
   - *b.* To gain favor
   - *c.* To place others in disfavor
9. STEALING
   - *a.* On the campus
     1. Minor (borders on borrowing)
     2. Major (stealing clothes or valuable property)
   - *b.* Off the campus
     1. Minor (stealing road signs, etc.)
     2. Major (automobile stealing, an example)
10. SEX TROUBLES
    - *a.* With same sex
    - *b.* With opposite sex
    - *c.* Obscenity
      1. With talk
      2. With pictures
      3. With literature

11. Immorality
    a. Combination of a few of habitual delinquencies
    b. Combination of many of habitual delinquencies
12. Narcotics
    a. Addict
    b. Peddler
13. Suicide

It must be remembered that there is no sharp line that can be drawn between one who is a delinquent and one who is not; delinquency is a matter of degree; and in the average college there are rules and regulations which, while they in themselves are not in use in the outside world, they are supplanted in life by other rules peculiar to the particular locality in which the young man is to live. It is difficult to get real statistics or reliable figures on the extent of crime in our colleges as but few colleges can afford to take the chance that the "college-boy pranks" will be interpreted by the public as otherwise.

It is doubtful that the riots which have occurred in the yards of some of our institutions have added anything to the character of those institutions.

While it is necessary for the educator to recognize delinquencies in their various degrees it is of even more importance that they recognize the causes and perhaps avert the tragedy that usually results from the neglect of these causes. With this idea in view there follows a list of drives which would tend to promote or cause delinquencies at the college level.

TABLE III

Drives Which Would Tend to Promote or Cause Delinquencies

1. Compensation for a Feeling of Inferiority
2. Unhappy Conditions Due to Being Away from Home
3. Desire to Be Accepted by Some Social Group
4. Lack of Orientation for Freshmen
5. Physical Disabilities
    a. Teeth
    b. Glands, etc.
    c. Height and weight
    d. Malformation
6. Mental Disabilities
    a. Due to some previous experience
    b. Reflecting family life
    c. Inherited
    d. Low intelligence
7. Scholastic Difficulties
    a. Due to lack of ability
    b. Due to lack of interest
    c. Due to lack of adaptability

8. Sex Activities or Abuses
9. Unhappy Sex Life
10. Lack of Money
11. Bad Associates
12. Corrupted by Adult Strangers
13. Undesirable Living Conditions
14. Undesirable Living Companions
15. Over-emphasis of Grades
16. Over-strict Discipline
17. Excessive Local Amusement Facilities
18. Misinterpretation of College Spirit
19. Misinterpretation of Freedom
20. Misinterpretation of Success
21. Need of Persuasion or Inspiration
22. Direct Fault of Faculty
    - *a.* Uninteresting or uninspiring courses
    - *b.* Cut and dried methods
    - *c.* Lack of knowledge of the student
    - *d.* Too much laxity
    - *e.* Letting things run themselves
    - *f.* In general, making possible any opportunity for a student to err.

This list of causes, while not all inclusive, indicates clearly the kind of elements that influence a student in doing wrong. In nearly every case the drive is environmental and can be controlled, if not entirely, at least to such a degree that delinquency will be minimized. In many cases this can be done by merely substituting desirable factors for undesirable ones. To do this, however, calls for a careful study of each case and above all the handling of these cases by one who understands conditions as they really exist.

VII

In the light of the foregoing it becomes the duty of the college, first, to provide healthy environment, secondly, to correct the offender if that is possible, and lastly, to punish him if necessary.

The determination of undesirable influences and their effect upon the individual might be placed in the hands of a specialist in this phase of education who could give his entire time, as well as that of his staff in a large institution, to the elimination of the causes of delinquencies and the treatment of specific cases. If there are weaknesses of a basic nature and they are caught in time and properly treated, a misdemeanor of a serious nature may be forestalled, save the college a lot of undesirable criticism, and above all, render a true service to the young man. In a small college, however, most of this work has to be done by the faculty and administration.

Where punishment is the only fair way to handle a case it should be dispatched with the utmost degree of fairness by some

person or group of persons whose express duty it is to investigate delinquencies. Whether it be the chief executive alone, the faculty as a whole, a committee of the faculty, a member of the faculty, or a student organization is purely a matter of detail in administration. In any event there should be no laxity in the enforcing of discipline, however, each case should be handled with due regard for the particular factors which influence it. Though the actual work is done by one of the above groups it must be remembered that this group represents the entire faculty, the students, the constituency and, in fact, the college. This being the case, the group should expect the highest coöperation from the faculty, administration and study body both in apprehending and prosecuting delinquents.

As we view the American college at this time in its attempt to prepare a student in a scholastic manner for life, we see in many the lack of any concerted effort in the direction of preparation for emotional life. It seems, therefore, that the time is ripe for the colleges in this country to unite in an effort to start students properly by creating an environment in their institutions which will reflect all that is good and healthy for the minds of students, not only while they are attending classes or lectures, but also in their dormitories, at their fraternity houses, at social functions, and, in fact, during their entire college life even at the expense of subject matter and mass-production.

The first step in this direction might be termed as a better "student-faculty" relationship where the experiences, the knowledge, and general background of the staff is made available to the student through a faculty, each member of which is so well founded in the principles of living that he will better understand the emotional life of the student, recognizing symptoms of common faults and then assist in their correction. At this instant we can at least acknowledge that we recognize the need for such a movement and then, as teachers, individually do all in our power to correct the situation in our daily contact with our students by being better examples for them to follow, by exercising a measure of control over situations coming under our jurisdiction and remaining conscious at all times to the problems of living with which these individuals are confronted. If we are willing to lead soon others will follow.

SCOPE AND ORGANIZATION OF A SEQUENCE OF COURSES IN STRUCTURES IN RELATION TO THE CIVIL ENGINEERING CURRICULUM *

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The specific purpose of a course in structures is to prepare the student to think and act in terms of the knowledge and skills composing the fundamental principles, technological information and engineering processes of this major phase of Civil Engineering. The scope of a course in structures includes the mastery of knowledge and the development of the power of constructive thought. The organization of a course in structures provides for the systematic attainment of these objectives in compliance with established principles of teaching methods.

General Objectives

Although the discussion in this paper is directed mainly to the sequence of courses in structures, the objectives of college education in general and engineering education in particular should be actively incorporated in the structural courses. College education is concerned with the stimulation, guidance, development and coördination of the students' advanced intellectual and mature social aptitudes. Engineering education supplements these general college objectives by stressing that special attitude of thought which encourages the application of the forces and materials of nature to the economic and social satisfaction of human needs and desires.

Personal Effectiveness

Definite efforts for the attainment of the college objectives should be made in all courses and at all time. Broadly speaking these objectives may be classified as development in personal and in social effectiveness.

Personal effectiveness consists of the traits by which the individual may expect to succeed intellectually. *Confidence* is brought about by the successful accomplishment of tasks by individual effort. *Initiative* may be developed by encouraging original ideas,

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methods and applications. *Thoroughness* may be achieved by insisting upon and demonstrating the value of completeness. *Industry* is essential to accomplishment and may be established by systematic, continuous and interesting application to work. *Enthusiasm* may be aroused and maintained by introducing material that is interesting to the student and that, by its very nature, is obviously important and useful. *Integrity* involves truthfulness in dealing with people and knowledge; professional ethics may be practiced by students long before they enter the field of engineering.

Social Effectiveness

Social effectiveness consists of the traits by which the friendship, knowledge and skills of the individual are sought and appreciated by his associates. *Appearance* should include neatness and taste in dress, physique, material possessions and work. *Physical vigor* should be in evidence not only in bodily strength and adroitness but intellectual alertness. *Social qualities* create spontaneously favorable response to surrounding social situations. *Tact* may be practiced regularly in the close associations between students and teacher; the class room and laboratory are favorable environments for fine mental discernment of the correct and kind things to do and say in critical circumstances. *Tolerance* may be developed by showing appreciation for the interests and methods of others and by assuming a reasonable attitude toward the success and shortcomings of others. *Cheerfulness* is a positive means of securing the friendly coöperation of others; regardless of the difficulty of a course the work should be so administered that the class is happy. Unpleasant associations are not sought and they seldom lead to permanent interest and retention. *Spirit of service* should be manifest in other environments than the Kiwanis or Rotary Club. Many of the principles, facts and methods that everyone uses daily are the voluntary contributions of society. The teacher all too often gives freely of his time, energy and skill. Selfishness is easily recognized and soon reaps its own reward of isolation. *Emotional control* should be practiced by the teacher as well as the student. Perhaps no other factor is so important in one's relation to his associates and in his power to influence human behavior.

Engineering Method of Thought

Engineering education has more definite and tangible objectives than general education. *Application* of knowledge toward the solution of a definite problem is the very foundation of engineering thought. *Logical and quantitative* consideration of problems is sought whether they be in the measurable physical or in the generalized social sciences. *Investigational* approach toward established facts, principles and proc-

esses characterizes the method for engineering progress. *Precision* is adjusted to the practical and economical necessities and possibilities of each situation. *Factors of safety* of known magnitude are introduced for expected but indefinite contingencies. *Conclusions* are based upon careful, orderly, thorough and unbiased consideration of pertinent conditions. *Results* are checked by as many independent methods as the importance of the project warrants.

These elements of personal effectiveness and characteristics of engineering thought have been briefly outlined. Their obvious merit and simple presentation should not put the engineering teacher off his guard. The quality and effectiveness of one's teaching depends, among other factors, upon the extent to which the students are given definite opportunities to acquire these personality traits and mental habits.

Structural Knowledge and Skills

Thinking has to take place in some specific field of knowledge. The range of knowledge even for a single subject like structures has become very extensive and specialized owing to the large number of purposes for which structures are used and owing to the tremendous development in structural theory, information and practice. Multiplying this development and intensification by the number of related branches usually associated with the general practice of Civil Engineering, and taking into account that four years are still considered the maximum length of an undergraduate engineering course, one immediately recognizes that scope and organization must deal with that essential knowledge which will serve the graduate adequately for immediate usefulness in supervised structural responsibilities and for future continuous study of new principles, information and processes.

With this viewpoint in mind the essential knowledge and skills of structural practice are surveyed and classified. The results of this study are then presented as the basis for organizing a sequence of undergraduate courses. The course content is selected and arranged to provide continuous experience in associating new problems with the basic principles, information and processes of engineering. By placing the emphasis on thinking in terms of structural knowledge the purpose of education is carried out in its broadest aspects.

Structural Types

Structures may be classified into a minimum number of individual types on the basis of the two criteria: (1) Position, Form and Arrangement, and (2) Reaction and Stress Characteristics. This classification is fundamental because each type may be readily

identified and because specific factual and theoretical knowledge may be associated with each type. These types are general in that they apply to all structures regardless of material or function. Take the *beam* as a structural type. It may be built of steel, timber or reinforced concrete. It may be used in a highway or railway bridge, as a part of a building, as an element of a cantilever wall, or for many other functional purposes.

The first step then in arriving at the scope of a course in structures is to establish a list of the basic structural types. These are:

1. Beam
2. Slab
3. Column
4. Truss
5. Trussed bent
6. Continuous frame
7. Arch rib
8. Dome
9. Space frame
10. Dam
11. Wall
12. Tank
13. Bin
14. Cable
15. Substructure

In practice these types occur individually or, more often, they are found in various combinations. The through truss railroad bridge is a good example of a complex structure (a structure composed of several basic structural types). The floor system consists of beams: ties to carry the rails, stringers to carry the ties and floorbeams to carry the stringers. The primary load carrying element consists of the two vertical trusses supporting the floorbeams. The top and bottom bracing system consists of trusses also. Transverse bracing consists of the trussed bents called portals and sway bracing. This example is of course obvious to the experienced designer but the student must learn to dissect complex structures into a number of structural types before he can make the first move either in analysis or design.

Dead and Live Loads

Structures are designed to carry loads. These loads may be classified into two groups. *Dead Loads* refer to the weight of the structure. *Live Loads* refer to all possible applied loads and secondary effects caused by live loads.

Dead loads are gravity loads. They are estimated from previous similar designs or they may be calculated from empirical weight formulas. The weights of roof trusses and bridges are available in most handbooks, texts, and professional literature.

Live loads may be classified into groups on the basis of their cause.

1. Gravity load
2. Wind pressure
3. Water pressure
4. Earth pressure
5. Earthquake vibration
6. Impact effect
7. Centrifugal force
8. Bulk pressure

The important gravity loads are those that are caused by (1) the weight of the structure, (2) snow, (3) storage and residental materials, (4) human beings, (5) livestock, (6) highway rolling stock, and (7) railway rolling stock.

Wind pressure is considered to act normal to the surfaces of a structure. In the case of large exposed volumes both positive and negative pressures should be considered. Reliable information is accumulating as a result of numerous wind tunnel experiments.

Water pressure effects are calculated for static and moving conditions.

Earth pressure magnitudes and effects are being studied intensively as soil physics and soil mechanics. The two important elements of earth pressure are its supporting value and its lateral thrust effect.

Earthquake vibrations are usually evaluated in terms of the gravity loads and the horizontal acceleration and displacement. The study of earthquake loads has led to a better understanding of other types of vibration effects on buildings.

Impact is of particular importance in bridge design. In certain industrial buildings the impact effect of moving loads needs to be considered. In residential buildings the impact effect of moving crowds is usually included as a part of the specified live load.

Centrifugal force is of particular importance in railroad bridge analysis when the structure is on a curve.

Bulk pressure is used here to denote pressure in storage structures. The materials most frequently encountered are sand, stone, coal, ore and grain.

Stress Analysis

For purposes of stress analyses and reaction computations each structural type may be classed either as statically determinate or as statically indeterminate. A structure may be statically indeterminate either with regard to stresses or reactions, or both stresses and reactions.

It is common practice to consider the complex structure to be divided into structural types each of which lies in a plane. Then each structural type is analyzed for the forces that lie in the same plane with it. Except in the case of space frames structural analysis deals with planar forces.

The stresses and reactions of all statically determinate structural types may be computed by the application of the three equations of static equilibrium:

$$\sum F_x = 0. \tag{1}$$

$$\sum F_y = 0. \tag{2}$$

$$\sum M = 0. \tag{3}$$

Graphic computations are frequently used in structural analysis either as a check of algebraic computations or as a means of direct reaction and stress analyses. Forces may be represented as vectors; a force is completely defined when its magnitude, line of action and direction are known. There are two fundamental graphic operations with forces: the first is called the composition of forces, finding the combined effect of two or more forces; the second is the resolution of forces, finding two or more components of a force.

When the forces meet at a point, equations (1) and (2) suffice to determine any two unknown values (magnitudes, lines of action or directions).

A *Force Polygon* is the graphic equivalent of equations $\sum F_x = 0$ and $\sum F_y = 0$.

When the forces do not meet at a common point, equations (1), (2), and (3) suffice to determine any three unknown values (magnitudes, lines of action, or directions).

An *Equilibrium Polygon* is the graphic equivalent of equations $\sum F_x = 0$, $\sum F_y = 0$, and $\sum M = 0$.

Bending Moment, M, and *Shear*, V, are two very useful concepts in structural analyses. Bending moment equals the algebraic sum of the moments of all external forces on one side of a section. Shear equals the algebraic sum of all external transverse forces to one side of a section.

The ordinate at a given point of an equilibrium polygon is proportional to the bending moment, M, at that point. The magnitude of M equals the ordinate of the equilibrium polygon multiplied by the pole distance of the corresponding force polygon.

The stresses in beams depend not only upon the external forces but also upon the shape and dimensions of the cross section. The effect of the external forces is represented by M and V. The shape of the cross section by I for fiber stresses, and $Q = \bar{y}A$ for shearing stress.

The unit tensile or compressive bending stress

$$f_v = \frac{My}{I}. \tag{4}$$

The unit horizontal or vertical shearing stress

$$v_h = \frac{VQ}{It}. \tag{5}$$

The equation of elastic curvature supplies one fundamental basis of computing the deflection of beams and of computing the moments, thrusts and shears in statically indeterminate structures.

The elastic curvature equation is derived in terms of the bending moment M, modulus of elasticity E, and moment of inertia I.

$$\frac{d^2y}{dx^2} = \frac{M_x}{EI}. \tag{6}$$

The first integral of Equation (6) gives the slope to the elastic curve.

$$\frac{dy}{dx} = \int \frac{M_x}{EI}\,dx. \tag{7}$$

The second integral of Equation (6) gives the deflection to the elastic curve.

$$y = \int \left[\int \frac{M_x}{EI}\,dx \right] dx. \tag{8}$$

Although the elastic curvature equation is very useful in the determination of deflections, it is still more useful as the fundamental principle on which more efficient methods of analysis are based. The following generalization of Equation (7) is of particular merit, it is called the first principle of Moment-Area:

"The angular deflections at the ends of any span are equal to the respective end reactions produced by loading that span with its moment area divided by EI."

The theorem of three moments, which provides a method of computing the bending moments in continuous and fixed beams, can be derived directly from an application of the first principle of moment area.

$$M_1\frac{L_1}{I_1} + 2M_2\left(\frac{L_1}{I_1} + \frac{L_2}{I_2}\right) + M_3\frac{L_2}{I_1} = -6\left(\frac{g_1A_1}{I_1} + \frac{g_2A_2}{I_2}\right). \tag{9}$$

In Equation (9) M's are the bending moments over the supports, L's are the span length, I's are the moments of inertia, A's are the areas of the simple beam moment diagrams, and g's are the distances to the centroids of the A's from the left end of span one and the right end of span two.

The slope-deflection equations, which provide a method of computing the bending moment in continuous beams and in continuous frames, can also be derived from the first principle of moment-area.

$$M_{AB} = 2EK(2\theta_A + \theta_B - 3R) \pm M^r_{AB}. \tag{10}$$

$$M_{BA} = 2EK(2\theta_B + \theta_A - 3R) \pm M^r_{BA}. \tag{11}$$

In equations (10) and (11) M_{AB} and M_{BA} are the moments at ends A and B, E is the modulus of elasticity, K is the ratio I/L for each member, θ_A and θ_B are the angular rotations at A and B, R is

the ratio D/L, and M^r_{AB} and M^r_{BA} are the fixed-end moments due to the loads on the span.

The moment distribution method is a very convenient procedure for the determination of moments in continuous beams and continuous frames.

The procedure is applied in three cycles. (1) The fixed-end moments are computed for all members. (2) The joints are balanced by distributing balancing moments to all members at a joint in proportion to the stiffness of the members. (3) A certain percentage of the balancing moments is carried over to the far end of each member. Cycles (2) and (3) are repeated until the desired precision is obtained.

As long as the moment of inertia of a frame member remains constant throughout its length, the fixed-end moments, stiffness and carry-over factors are readily available. When the moment of inertia is variable throughout the length of a member the first principle of moment-area may be directly applied to obtain these values. Then the moment distribution method can be applied in the usual manner. Sidesway may result in a continuous frame either from lateral loads or from unsymmetrical gravity loads. In these cases the moment distribution method may still be applied provided the *shear-moment* is kept constant at the end of the third cycle.

The most generally but not always the most conveniently applicable principle of structural analysis is that of the strain-energy theory. It may be employed to compute deflections of beams or trusses, stresses in redundant truss members, stresses in arch ribs, redundant reactions, continuous frames, and stresses and reactions in trussed frames. The principle is based upon the work equation in which W = work, F = force, and d = displacement.

$$W = Fd. \tag{12}$$

The force is the axial stress, S, in a member and the displacement is expressed in terms of the stress, S, and modulus of elasticity, E. Also, the stress increases from zero to its maximum value; therefore the average force $\frac{1}{2}S$ may be used. Then the work in an axially stressed member is

$$w = (\tfrac{1}{2}S)\left(\frac{SL}{EA}\right) = \frac{S^2L}{2EA}. \tag{13}$$

The work performed in stressing a beam may be derived in a similar manner, giving

$$w = \int \frac{M^2 ds}{2EI}. \tag{14}$$

A unit load may be applied in the direction of the desired displacement at a truss joint. The work performed upon this unit load by the displacement caused by the applied loads must equal the summation of the work in all the members. The work in each member equals the change in length produced by the applied load multiplied by the stress caused by the unit load. If D is the displacement at a joint, u is the stress caused by the unit load, and d is the change in length caused by the applied loads, then

$$D = \mu d = \Sigma \frac{SL}{EA} u. \tag{15}$$

The displacement of truss joints may be graphically determined by the construction of a Williot diagram using the computed changes in length caused by the applied loads.

Redundant reactions for continuous trusses and two-hinged truss arches may be determined by first computing for the applied loads the deflection D with the reaction removed, then computing for a unit load at the reaction the deflection d. The reaction R will then equal D divided by d.

$$R = \frac{D}{d} = \frac{\Sigma \frac{SL}{EA} u}{\Sigma \frac{u^2 L}{EA}}. \tag{16}$$

Equation (16) also represents the value for a single redundant truss member. It may be derived directly from Equation (15). The stress, S, is the stress in all members when the redundant member is not acting. The stress, u, is the stress in all members, including the redundant member, when a unit load is applied in the line of action of the member.

The stresses in trusses with any number of redundant members may be computed by taking the partial derivative of the work with respect to each unknown. Then as many separate equations may be written as there are redundant members. The solution of these equations will yield the desired redundant stresses.

Stresses in trussed frames such as the portal or sway bracing, the transverse bent of industrial buildings, and trussed beams may be computed by applying Equation (13) to the members carrying axial stresses and Equation (14) to the members carrying bending stresses.

Stresses in arches, closed rings, and U-bents with varying moment of inertia may be calculated by using the summation

equations derived from the theoretical curved beam equations or directly from the work Equation (14).

$$\Delta\varphi = \sum \frac{Ms}{EI}. \tag{17}$$

$$\Delta x = \sum \frac{Mys}{EI}. \tag{18}$$

$$\Delta y = \sum \frac{Mxs}{EI}. \tag{19}$$

The procedure in these calculations is to divide the arch axis into a number of segments. The unknowns M_c, H_c and V_c are applied at the crown of the arch. Then the coördinates, x and y, are measured from the crown, c, to the center of each segment, s. The moment of inertia of the cross section at the center of each segment is computed. The values of M in equations (17), (18) and (19) are for the applied loads and the unknowns M_c, H_c and V_c. A solution of the three equations will give the magnitude of the unknowns at the crown. Then the moments, shears and thrusts at all other points may be computed. Other computations should be made for effect of change in temperature, rib shortening due to compression, and shrinkage of concrete.

Equations (1) to (19) present the mathematical expressions for the structural theory usually included in the undergraduate courses in structures.

Model analysis has come to play an important part in structural research and in checking the theoretical analyses of structures. The model is designed in accordance with established principles of similitude. The mechanics properties of the model have a definite scale relationship to the prototype. The model is not a miniature structure.

In the case of bridge analysis moving loads must be placed so that they will produce the maximum stress effects in all portions of a structure. The influence table and the influence diagram provide the two most generally used methods for determining the direct and reverse stresses, as well as maximum and minimum stresses, produced by moving loads.

An influence table is built up by placing a unit load at one panel point at a time and computing the stresses in all members for each position of load. The completed influence table will indicate what portions of a structure need to be loaded in order to produce direct and reverse stress effects. The stresses resulting from the unit loading may be computed by any desired method.

Influence diagrams indicate how a desired function varies at some fixed point as a unit load moves across a bridge. The variables

are usually shear, bending moment, or stress. An effective approach to the understanding of influence diagrams is to plot the variation of stress in a given member for different positions of the unit load. The length of the ordinates equals the stress in the member; the position of the ordinate is at the position of the unit load. In beam, girder and truss bridges the stresses in the chord members are proportional to the bending moment; the stresses in the web members are proportional to the shear. As a rule influence diagrams for shear and bending moment may be constructed by simple calculations.

The actual spacing of a system of moving loads may be determined by criteria for shear, bending moment and stress. As a rule the maximum shear at a given point is produced by placing the first, second or third wheel at the point. The maximum bending moment at a given point is determined by the following criterion:

$$\frac{w_1}{a} = \frac{W}{L}. \tag{20}$$

Equation (20) indicates that the maximum moment at a point is obtained when the intensity of load on the short segment equals the intensity of load on the whole span. This criterion may be applied to inclined chord trusses as well as parallel chord truss.

The criterion for the placing of live loads in order to give the maximum stresses in the web members of trusses with inclined chords is:

$$\frac{w}{p} = \frac{W}{L}\left(\frac{a}{a+c}\right). \tag{21}$$

In Equation (21) w is the load on panel length p, W/L is the intensity on the whole span, "$a/(a+c)$ is the ratio of the distances to the intersection of the chords from the left reaction of the truss and from the left reaction of the panel which includes the member."

Briefly then the criteria indicate where to place the system of live loads and the influence table or influence diagram serve to calculate the desired shear, bending moment or stress.

Design

Design consists of determining the size, shape, details, connections and arrangement of the various basic structural types. The factors that must be taken into account are the physical properties of the materials, the total amount of stress to be carried, the type of stress, and the safe permissible amount of unit stress to use.

The most commonly used structural materials are steel, timber and concrete (plain and reinforced). Other important materials

are aluminum, brick, clay tile and reinforced gypsum. The common physical properties of these materials are durability, elasticity, ductility, stiffness, resilience, toughness, hardness, endurance, Poisson's ratio and mechanical hysteresis. Each material responds in its own characteristic manner to the basic strains of axial tension and compression, bending tension, compression and shear, direct shear, torsional shear, bond shear, and bearing.

Structural types may be classified into one of three basic groups for purposes of design.

1. Axial (tension and compression) members.
2. Bending (tension, compression, shear and bond) members.
3. Combined axial and bending members.

The stress in tension members is assumed to be uniformly distributed over the cross section. In designing a tension member the following simple relationship is used,

$$A_n = \frac{S}{f_t}, \qquad 1$$

where A_n is the net area of the member, S is the stress in the member and f_t is the allowable unit stress of the material.

Short compression members subject to centrally applied loads are also assumed to have the stress uniformly distributed over the cross section. When A_g equals the gross cross section the following relationship holds:

$$A_g = \frac{S}{f_c}. \qquad 2$$

In the case of columns and truss members in compression, even when the loads and stresses are axially applied, some tendency to buckle is present. To allow for this three types of column formulas are in use in steel design.

$$\frac{P}{A} = \frac{18000}{1 + \frac{L^2}{18000r^2}} \quad \text{(Rankine-Gordon).} \qquad 3$$

$$\frac{P}{A} = 18000 - 70\frac{L}{r} \quad \text{(Straight Line).} \qquad 4$$

$$\frac{P}{A} = 15000 - \frac{1}{4}\left(\frac{L}{r}\right)^2 \quad \text{(riveted column)}$$

(Parabolic). 5

$$\frac{P}{A} = 15000 - \frac{1}{3}\left(\frac{L}{r}\right)^2 \quad \text{(pinned column)}$$

In timber design two column formulas are available. The A.R.E.A formula is

$$\frac{P}{A} = f_c\left(1 - \frac{L}{60d}\right). \qquad 6$$

The Newlin-Gahagan formula is

$$\frac{P}{A} = f_c\left[1 - \frac{1}{3}\left(\frac{L}{Kd}\right)^4\right] \quad \text{where} \quad K = 0.64\sqrt{\frac{E}{f_c}}. \qquad 7$$

Reinforced concrete columns must take into account the difference in stiffness between the steel and concrete. The A. C. I. formula for spirally reinforced columns is

$$P = A_g(0.22f_c' + f_s p_g). \qquad 8$$

In this equation P is the maximum allowable load on the column, A_g is gross area of the column, f_c' is the compressive strength of the concrete, f_s is the working stress in vertical reinforcement, and p_g ratio of the effective cross sectional area of the vertical reinforcement to the gross area A_g. For additional recommendations see the A. C. I. specifications.

The unit fiber stress in bending members of homogeneous materials such as steel, timber or aluminum is given by the formula,

$$f_v = \frac{My}{I}. \qquad 9$$

The unit horizontal shear and unit vertical shear are given by the formula,

$$v_h = \frac{V(\bar{y}A)}{It}. \qquad 10$$

For combined materials like reinforced concrete beams the fiber stress in the steel and concrete may be determined in terms of the resisting moment and relative stiffness of the materials,

$$f_s = \frac{M_s}{A_s jd} \quad \text{(unit stress in steel)}. \qquad 11$$

$$f_c = \frac{M_c}{\frac{1}{2}kjbd^2} \quad \text{(unit stress in concrete)}. \qquad 12$$

Combined axial and bending stresses occur when beams are subjected either to tension or compression. These instances occur when the bottom chord or top chord of a bridge carries transverse loads. Columns in multistory continuous frames and in the transverse bent of industrial buildings are also subject to combined stress. When the materials are homogeneous a common practice

is to assume that the existing combined stress is a direct combination of the axial and the bending stresses.

$$f_t = f_c = \frac{P}{A} \pm \frac{Mc}{I}. \qquad 13$$

Connections and details are important phases of structural design. Timber connectors are nails, spikes, screws, bolts, and patented steel connectors. Steel members are connected either by pins, rivets or by welding. Concrete is poured in place; the connections are made by splicing the steel reinforcing rods to provide adequate bond and continuity.

Structural design has developed by gradual evolution as more definite principles were established, as the properties of materials have been improved, as more effective details were worked out, and as the workmanship became better. Certain specifications for assuring good, effective and efficient designs are available.

The Forest Products Laboratory has prepared a Wood Handbook which gives basic information on wood as a material of construction with data for its use in design and specifications. Additional useful design tables are available from the Douglas Fir and Southern Pine manufacturers.

The American Concrete Institute has issued specifications for Building Regulations for Reinforced Concrete.

The American Institute of Steel Construction issues a handbook on Steel Construction. This volume contains specifications, design tables, properties for designing, and dimensions for detailing along with other useful information.

Building Codes include specifications and instructions governing safe practice in building design. The 1937 Edition of the Uniform Building Code issued by the Pacific Coast Building Officials' Conference is a good example of this type of publication.

The American Association of State Highway Officials has issued a set of Standard Specifications for Highway Bridges.

The American Railway Engineering Association regularly issues revised specifications for spans not exceeding 400 feet in length. The latest edition of Specifications for Steel Railway Bridges may be found in *Proceedings*, Volume 36, 1935.

Related Functional Operations

Analysis and design are the two functional operations that lend themselves better for teaching and learning at college than in practice. However, at college only a foundation of fundamentals can be acquired in the short time allotted to courses in structures.

There are nevertheless other functional operations in structural engineering about which the student should know. Some shop

detailing should be introduced in order to carry design through to the point where it is ready for fabrication.

Estimating of quantities and costs is useful in establishing some ideas as to the economic advantage of one type of structure over some competing type.

Economic selection between different types, different materials, or different proportions within the same type, helps to develop judgment.

Planning proportions, selecting types, and choosing materials offer excellent outlets for the development of creative skill in structural engineering.

Study of the erection of superstructures of various types as well as different foundation construction tend to broaden the student's comprehension of the whole field. Thereby he can work out the portions assigned to him more adequately.

Time devoted to study of details, fabrication, erection, economic selection, estimates and planning round out the course and make analysis and design more real and purposeful.

Organization of Courses

In his paper on "Trends in Structural Engineering," Professor Hale Sutherland said, "The teacher considers the trends in structural engineering so that he may be enabled to shape both individual courses and the curriculum for maximum educational efficiency, to the end that the graduate be competent in essential fundamentals, familiar with all major techniques both of analysis and of construction, soundly oriented in this fast developing field."

The following outline of structural courses has been worked out with due consideration of a well balanced four-year curriculum in Civil Engineering. The courses in Strength of Materials, Properties and Testing of Materials, and Construction and Foundations are indicated in the sequence because they constitute inseparable elements of the knowledge and skills that are usually associated with structural engineering. Yet the general field of mechanics, foundations and construction are necessary phases of the other branches of Civil Engineering—Transportation Systems, Sanitary Works, Hydraulic Projects and Related Fields. Therefore in estimating the ratio of time devoted to structural courses it seems reasonable to exclude the time allotted to mechanics, foundations and construction.

Curriculum of Structural Courses

Two sequences will be presented; one for use where the quarter system is in vogue, the other for the semester system. In order to allow for registration, examination week and holidays the effective

academic year will be taken as 30 weeks in length; this arrangement allows for three quarter periods, each 10 weeks in duration or two semester periods, each 15 weeks in duration. Actually the academic year consists of 36 weeks; of these six weeks have been allowed for classification, holidays and final examinations. The remaining 30 weeks represent full working time. In order that the amount of time devoted to each course shall be the same in both systems, the total number of hours was made the basis of time distribution.

On the basis of a 54-hour week, or 9 hours per day for a 6-day week, there are 1620 hours in an academic year; this allows 540 hours per quarter and 810 hours per semester.

It is considered fair to assume that the student shall spend on the average two hours in outside preparation for each recitation period. Furthermore, no outside expenditure of time is expected for the satisfactory completion of laboratory assignments; however, students who are below the average in intellect or speed may rightfully be expected to carry a reduced schedule so that they may devote more time to each course.

TABLE I

STRUCTURAL COURSES IN THE JUNIOR YEAR

Semester System

Fall	Hrs.	Spring	Hrs.
Strength of Materials, 4 Rec.	180	Elements of Structures, 2 Rec. and 1–4 hr. Lab.	150
Properties and Testing of Materials, 2 Rec. and 2–3 hr. Lab.	180	Reinforced Concrete Design and Technology, 2 Rec. and 1–2 hr. Lab.	120
	360		270

Quarter System

Fall	Hrs.	Winter	Hrs.	Spring	Hrs.
Strength of Materials, 5 Rec.	150	Testing Materials, 1 Rec. and 1–3 hr. Lab.	60	Concrete Testing, 2–3 hr. Lab.	60
Properties of Materials, 2 Rec. and 1–3 hr. Lab.	90	Elements of Structures, 3 Rec. and 2–3 hr. Lab.	150	Reinforced Concrete Design and Technology, 3 Rec. and 1–3 hr. Lab.	120
	240		210		180

Four courses are recommended for the junior year as shown in Table I. These courses are Strength of Materials, Properties and Testing or Materials, Elements of Structures and Reinforced

Concrete Design. Out of a total of 1620 hours of college work the student spends 270 hours or about 17 per cent on structures, and 360 hours or about 22 per cent on mechanics. It seems entirely reasonable, therefore, to devote one-sixth of the junior year curriculum to structures in view of its general importance to the Civil Engineer.

TABLE II

STRUCTURAL COURSES IN THE SENIOR YEAR

Semester System

Fall	Hrs.	Spring	Hrs.
Bridge Analysis, 2 Rec. and 1–4 hr. Lab.	150	Advanced Structural Analysis, 2 Rec. and 1–4 hr. Lab.	150
Masonry Structures and Concrete Buildings, 2 Rec. and 1–4 hr. Lab.	150	Construction and Foundations, 4 Rec.	180
	300		330

Quarter System

Fall	Hrs.	Winter	Hrs.	Spring	Hrs.
Bridge Analysis, 3 Rec. and 2–3 hr. Lab.	150	Masonry and Concrete Buildings, 3 Rec. and 2–3 hr. Lab.	150	Advanced Structural Analysis, 3 Rec. and 2–3 hr. Lab.	150
Construction and Foundations, 2 Rec.	60	Construction and Foundations, 2 Rec.	60	Construction and Foundations, 2 Rec.	60
	210		210		210

Options for Majors in Structures

Course	Semester	Quarter
1. Soil Mechanics	2–3 Rec. Courses	3–3 Rec. Courses
2. Space Frames	1–3 Rec. Courses	2–3 Rec. Courses
3. Industrial Buildings	2–3 Rec. Courses	3–3 Rec. Courses
4. Multistory Buildings	2–3 Rec. Courses	3–3 Rec. Courses
5. Storage Structures	1–3 Rec. Courses	2–3 Rec. Courses
6. Model Analysis	1–3 Rec. Courses	2–3 Rec. Courses

The proposed curriculum shown in Table II for structures in the senior year is divided into three groups; first the required courses are given for the semester and the quarter systems, second a set of options are listed for undergraduates majoring in structures, and third suggested honors work is indicated for students of exceptional scholarship. Four required courses are recommended for all students of Civil Engineering. These courses are Bridge Analysis, Masonry Structures and Concrete Buildings, Construction and

Foundations, and Advanced Structural Analysis. Out of a possible total of 1620 hours per year, this sequence calls for 450 hours or about 28 per cent for structures, and 180 or about 11 per cent for construction and foundations. Again these percentages of the total available time in the senior year appear reasonable in the light of the significance of structural courses in the Civil Engineering curriculum.

Honors Courses

Special experimental investigations and collateral study of current structural literature.

Course Contents

The contents of each course are selected on the basis that the principles, technical information and engineering practices are absolutely essential and generally applicable in future structural thought and practice. The basic fundamentals of structures have been presented and discussed in that part of this paper which deals with Engineering Knowledge and Skills. The author has presented in a previous article, "Teaching Applied Courses," JOURNAL OF ENGINEERING EDUCATION, June 1937, p. 747, certain criteria that should guide teachers in planning the manner in which they present subjects. Although many basic principles were taught in the Statics and Strength of Materials courses there still remain new theories, new materials, new processes, and improved methods to take up in the structural courses.

The scheme followed in these suggestions is to combine analysis and design. Since the purpose of the course has been stated as the mastery of knowledge and the development of constructive thought, advantage will be taken to provide the student with appropriate environmental conditions for the efficient attainment of the proposed objectives. The course contents will be presented as a series of problems. The length and difficulty of each problem will increase as the course progresses. The advantage of this method is that the student needs to associate related information, method, and practice with each new problem. This makes it necessary for him to recall and recognize previous knowledge. Furthermore, an intense need is created for the material and therefore the mind becomes very earnest in seeking new knowledge and re-learning old knowledge.

In order to avoid constant repetition the fundamental principles, structural types, functional operations, and details and connections will not be repeated. The author feels that his readers are adequately familiar with the subject to recognize that through all the courses the student is continually reviewing previously acquired

knowledge. It is also evident to the experienced that the solution of each new problem is but the stepping stone to the mastery of knowledge and development of thought.

Elements of Structures (Semester: 2 Rec. and 1–4 hr. Lab.; quarter: 3 Rec. and 2–3 hr. Lab.)

1. *Reaction Computations.*—Algebraically and graphically. Simply supported beams and trusses. Approximate solution for two-hinged roof trusses. Exact solutions for three-hinged arches. Bending moment and shear diagrams. Equilibrium polygons through three points. Use of the equilibrium polygon as a bending moment diagram.
2. *Stresses.*—All forms of simply supported statically determinate trusses. Static loads. Analysis methods: equilibrium of joints, equilibrium of sections, stress diagrams and coefficients. Graphic and algebraic methods.
3. *Beams.*—Review of beam stress analyses for rolled sections and unusual sections using only the equations of equilibrium. Design of timber and steel beams. Design of simple beam and column framing. Deflection of beams.
4. *Girders.*—Complete analysis and design of a plate girder. Only general drawings required.
5. *Roof Truss.*—Load determination, stress analysis, design, and shop detail of roof truss.

Reinforced Concrete Design (Semester: 2 Rec. and 1–2 hr. Lab.; quarter: 3 Rec. and 1–3 hr. Lab.)

1. *Engineering Practice.*—Methods of proportioning concrete. Forms. Curing.
2. *Fundamental Theory.*—Slabs. Beams. Columns. Footings. Combined axial and bending stresses.
3. *Continuous Beams.*—Derivation of the theorem of three moments by the application of the moment-area principle. Solution of typical problems.
4. *Design.*—Slab and girder bridges. Typical slab, beam and girder floor of a building.
5. *Detail Drawings.*—Fabrication details either for the bridge or building design.

Bridge Analysis (Semester: 2 Rec. and 1–4 hr. Lab.; quarter: 3 Rec. and 2–3 hr. Lab.)

1. *Influence Tables.*—The bridge frame. Amount and distribution of dead load. Application of live loads. Direct and reverse stresses. Maximum and minimum stresses. Influence tables.
2. *Parallel Chord Trusses.*—Coefficient method of analysis. Maximum and minimum stresses. Counters.

3. *Simple Trusses with Inclined Chords.*—Unit reaction method (graphic). Influence diagrams for shear, bending moment and stress.
4. *Moment Criteria.*—Determination of load position for maximum bending moment at a given point. Determination of load position for maximum bending moment under one of the loads.
5. *Tables and Diagrams.*—Locomotive wheel loads. Highway wheel loads. General moment table. Maximum moments, shears and reactions for Class E-10 and Class M-10 Engine Loading. Curves of equivalent uniform loads. E-60 and M-60 (Steinman's charts).
6. *Economics of Bridge Design.*—Conditions governing the proportions and design of bridges. Economic factors both major and minor. Economic selection. Financial data. Mathematical relation between cost and proportions of a structure.
7. *Investigation.*—The laboratory work in this course consists of the investigation of an existing highway bridge of recent design. The stress analysis and redesign of this structure according to an available set of specifications make an excellent problem in increasing knowledge and promoting thought.

Masonry and Reinforced Concrete Buildings (Semester: 2 Rec. and 1–4 hr. Lab.; quarter: 3 Rec. and 2–3 hr. Lab.)

1. *Dams.*—Design of gravity dam. Review of earth and rock dams, arched dams, hollow dams. Water pressure. Rock foundation pressure. Drawing of graphical analysis.
2. *Retaining Walls.*—Lateral earth pressure theories. Stress computations. Design. Detail drawings.
3. *Concrete Building Design.*—Derivation of the moment distribution method for beams and columns of uniform cross sections. Analysis of two or three story warehouse type of building. Study of maximum loading conditions. Design of typical slab, beam, girder, column, and footings for wall and interior columns. Combined footings. Detail drawing of typical elements.

Advanced Structural Analysis (Semester: 2 Rec. and 1–4 hr. Lab.; quarter: 3 Rec. and 2–3 hr. Lab.)

1. *Deflection of Trusses.*—Graphic Williot method. Algebraic method of work. Symmetrical and unsymmetrical loading.
2. *Redundant Reactions (Trusses).*—Method of deflections. Reaction computations for a continuous span and for a two-hinged arch.

3. *Redundant Members (Trusses).*—Strain-energy theory for axially loaded members and for bending members. Stresses in highway bridge truss with two counters. Stresses in trussed beam.
4. *Arch Ribs.*—Curved beam theory. Complete stress analysis of a fixed arch. Temperature effect. Rib shortening. Shrinkage effect.

TABLE III

OUTLINE OF COURSES IN STRUCTURAL ENGINEERING
ANALYSIS OF STRESS AND STRAIN

		Strength of Materials	Structural Analysis Determinate	Structural Analysis Indeterminate
Principles	Fundamentals Derived	Composition and Resolution of Forces Stress and Strain Static Equilibrium Types of Stress Tension Compression Bending Shear Bearing Torsion Point of Contraflexure	Direct Stress Composition and Resolution of Forces Funicular Diagram Equilibrium Polygon Method of Joints Method of Shear Method of Moments Direct Strain Bending Stress Tension Compression Shear Graphic Presentation Shear Moment Deflection Williot Diagram Influence Lines Mechanical Analysis	Bending Stress Tension Compression Shear Graphic Presentation Shear Moment Influence Lines Mechanical Analysis
Structural Types	Statically Determinate	Beams Reactions Shear Diagrams Moment Diagrams Influence Lines Columns Methods Columns and Beams Combined Stress Direct and Bending	Beams Simple Cantilever Railroad Loading Derricks Towers Trusses Roof Fink Fan Pratt Cantilever Stadium Bridge Uniform Load Max. and Min. Stress Moving Load Influence Lines Moment Tables Three Hinged Arch	
	Indeterminate	Simple Elastic Beams Deflection Double Integral Area Moments Continuous Beams Three Moment	Portal Mill Bent	Continuous Beams Stiff Frames
Term		First Junior	Second Junior	Elective Second Senior

Note.—Prepared by Professor James R. Griffith, Oregon State College, Department of Civil Engineering.

TABLE IV

OUTLINE OF COURSES IN STRUCTURAL ENGINEERING DESIGN AND DETAIL, MEMBERS CONNECTIONS AND MASS UNITS

	Reinforced Concrete	Riveted Steel	Timber	Welded Steel and Reinforced Brick Masonry
Principles Fundamentals Derived	Internal Stress and Strain Mod. of Elasticity Static Equilibrium Direct Stress Short Column Plain Reinforced Bending Stress Tension Compression Shear Bond Combined Specifications	Internal Stress and Strain Mod. of Elasticity Static Equilibrium Direct Stress Tension Compression Bending Stress Tension Compression Shear Combined Deflection Shop Details Specifications	Internal Stress and Strain Mod. of Elasticity Static Equilibrium Direct Stress Tension Compression Bending Stress Tension Compression Shear Combined Deflection Specifications	*Welding and Cutting Types, Methods* Internal Stress and Strain Direct Stress Bending Stress Specifications --- *Reinf. Brick Masonry* Bending Stress Direct Stress Specifications
Structural Types Statically Determinate	Beams Reinforced for Tension Balanced Unbalanced Web Reinforcing Reinforced for Comp. T-Beams Slabs Column Tied Spiral Reinforced Typical Bay	Lintels Floor Beams Crane Girders Purlins Mill Bldg. Cols. Anchor Bolts Braces Brackets Roof Trusses Highway Thru Girder Bridge	Floor Beams Joists Concrete Forms Ry. Stringers Howe Ry. Truss Roof Truss	Welded Steel Industrial Bldgs. Highway Bridges *Reinf. Brick Masonry* Slabs Beams Retaining Walls
Indeterminate	Continuous Beams			
Term	Third Junior	First Senior	Second Senior	Third Senior

Note.—Prepared by Professor James R. Griffith, Oregon State Agricultural College, Department of Civil Engineering.

5. *Rigid Frame.*—Application of curved beam theory to rigid frame with peaked roof.
6. *Slope Deflection.*—Derivation of slope deflection equations by the moment-area principle. Application to continuous frame. Check continuous frame results by moment distribution. Side sway.

Professor James R. Griffith has arranged a sequence of structures courses on the basis of separating the functional operations of analysis and design. He presents both analysis and design in terms of the fundamental principles involved, the structural types employed, and the statical condition of the structure. This organization is shown in Tables III and IV which he very kindly sent for consideration in this discussion. By the inclusion of Professor

Griffith's charts the reader may weigh for himself the relative merits of either combining or separating analysis and design. Tables III and IV are planned for the quarter system.

Regardless of the method used to teach structural courses opportunities should be included for planning and estimating. Current practice in design, details, fabrication and erection could be introduced by well chosen illustrated lectures and carefully assigned collateral reading.

The author wishes to acknowledge his indebtedness to Professors A. H. Fuller and R. A. Caughey with whom he has frequently had occasion to discuss the scope and organization of structural courses. In arriving at the analysis and curriculum presented in this paper the course outlines of twelve typical institutions were studied and the contents of twenty textbooks were consulted.

In closing the author wishes to make it clear that he does not consider his analysis of the problem final. He does feel that he has made a start in presenting the minimum essentials of structures. With these the student may enter the profession so that his more experienced engineering associates will discern that he has mastered the basic knowledge and shows powers of mastering new situations.

STATUS OF ENGINEERING DEGREES

By O. M. LELAND

Dean, University of Minnesota

Two years ago this Society adopted a new policy regarding the forms of engineering degrees, upon the recommendation of its Committee on Degrees and following a letter ballot of the entire membership. Inquiries received by the Secretary as to the extent to which changes in degree practice have been made in connection with the consideration of the subject in recent years, led to his suggestion that a brief study be made and the results reported to the Society at this meeting. A few questions were formulated which were sent out by the Secretary to the various engineering schools and the replies, generally from the deans, were mailed to the writer for compilation and study. The following notes and comments are based upon these replies.

The questions were sent to about 150 schools. Replies were received from 96 of the 108 active, and 12 of the 28 associate, institutional members, and 4 non-members, a total of 112, that is 75 per cent. Owing to limited time, no follow-up letters were sent.

Thirty-seven schools (33 per cent) report that some change was made in their degrees within recent years. In a few instances new degrees were added without changing the type. It is more significant, perhaps, to note that 75 (67 per cent) report *no changes.* Some schools have "degree traditions," as they might be termed, which seem to preclude changes of any sort. Especially is this apparent where the academic degree, A.B. or B.S., is used for all of the courses in the institution.

Changes are under consideration at thirty-three schools (30 per cent). Certain ones report that they have the new plan under discussion and expect to adopt it. Others state that they are purposely waiting "to see what the other schools do." The deans of four schools only, register their disapproval of the new plan and do not contemplate its adoption.

The present practice among the schools reporting, for the first —or bachelor's—degree, is indicated by the following table:

B.S or A.B.	18
B.S. (C.E.)	63
B.C.E. or B.E.	28
C.E.	3
	112

These figures show some interesting trends. In the first place, there is a definite increase in the schools which have adopted the Society's recommendation of the B.C.E. type of bachelor's degree, that is, omitting the words "Science in" from the previous form B.S. in C.E. Twenty-eight schools report this adoption. Of these five use the bachelor of engineering (B.E), namely, Johns Hopkins, McGill, Toledo, Tulane, and Yale. At Johns Hopkins, the B.E. is followed by M.C.E. and Dr. Eng. Yale uses B.E., M. Eng., and D. Eng., which corresponds in principle to the Society's plan, that is, omitting the word "Science." but, on the contrary, uses the honorary form for the earned doctorate.

In this connection, it is interesting to note that 52 schools use some degree of the recommended type outside of engineering. LL.B. is quite general. B.Arch. is used by various schools, notably M. I T. which uses S.B. for all its other engineering courses. B.Mus. and B.F.A. (fine arts) are used by a number of schools which use the B.S. (C.E.) type for engineering. Thus the principle of the Society's form, the word bachelor and the name of the professional field, as civil engineering, architecture, law, or music, without the interposition of the word science or arts, is recognized in some degree or degrees in a large number of schools. At the A. & M. College of Texas, the professional character of the new five-year courses in petroleum engineering and architecture is shown by the degrees B.Pet.E. and B.Arch. although the four-year courses in engineering still use the B.S. degree without course designation.

On the other hand, 18 schools adhere to the academic degrees A.B. and B.S. for all courses including engineering, and without indication of the course pursued, notwithstanding the action of this Society more than 25 years ago recommending that the course be included in the degree as B.S. (C.E.).

The trend away from the use of the professional degree (C.E., M.E., E.M., etc.) as a first degree, corresponding to the bachelor, is positive and approaching its limit of zero. Only three schools appear to be using this type, namely, Colorado School of Mines, Stevens Institute of Technology (M.E. only), and the University of Cincinnati. Moreover, both Stevens and Cincinnati report that a change is under consideration. The discontinuance of this practice among some of the oldest of our engineering schools was undoubtedly promoted by the action of the Society, thus clearing the way for a simplification of the degree structure in engineering.

Twenty-one schools report no graduate degrees in engineering. Eleven use either or both M.C.E. and D.C.E. Yale and McGill use M.Eng. as the regular master's degree. The professional form (C.E.) is used in place of the master's degree for one year of graduate work at Princeton, Columbia, Rice Institute, and Virginia

Polytechnic Institute, and for two years of graduate work at Stanford and the University of California. A movement seems to be in progress among the schools of business administration in the same direction as that of our Society's action, namely, towards the use of the M.B.A. degree instead of the M.S. or M.S.(B.A.). It is in line with the recognition of business administration as a profession.

The professional degree (C.E., etc.) is still used by three schools as a first (bachelor's) degree and by six schools in place of the master's degree in course, as mentioned above. Seven schools use it as an honorary degree. Thirty schools report that it is *not* used. Still, 67 appear to be using it for recognition of alumni professional practice although the number of such degrees awarded seems to be very small. Marquette specifies state registration as part of its requirement for this degree.

Forty-six schools report that no honorary degrees in engineering are awarded. At forty, the M.Eng. and/or D.Eng. are used and at twenty-six, the M.S. and/or D.Sc. are used for this purpose. Seven schools use the professional type (C.E.) for honorary degrees in engineering, namely, Arizona, Colorado State College, Michigan State College, Norwich, Santa Clara, Texas A. & M., and Vermont, although very few of such degrees seem to have been awarded.

Viewed broadly and in the light of the history of degree practice in engineering schools, the progress towards the adoption of the Society's recommendations as shown by this study must be regarded as quite satisfactory. Twenty-three schools have adopted the B.C.E. form and five others the B.E. type. In addition, several have the change under consideration. The deviations from the more widely prevalent practices seem to be less numerous than they were a few years ago, although there are many remaining. The adoption of the B.C.E. form by many other professions should promote its further adoption in engineering. Architecture, forestry. business administration, fine arts, law, landscape architecture, music, divinity, and medicine are but a few of these examples.

In the graduate field there seems to exist the idea that the M.C.E. degree must of necessity be administered by the engineering college rather than by the graduate school, and similarly the doctorate (D.C.E.). That this is not the case is shown by various examples. The form of the degree need not determine the type of administration. It is obvious, of course, that the advanced work of engineering should be supervised by the engineering staff.

IMPACTS OF THE E. C. P. D. ACCREDITING ON PHYSICS *

By DANIEL S. ELLIOTT

Professor of Physics, Tulane University

The recent accrediting of engineering courses by the Engineers' Council for Professional Development is probably the most significant happening in engineering education since the investigation of engineering education by the S. P. E. E. under the direction of Doctor Wickenden. It is important, therefore, to those interested in physics at engineering schools to consider the impacts of this E. C. P. D. accrediting on physics.

The writer bases his right to make this inquiry on a quarter of a century of happy association with engineers and engineering education. He chooses the annual meeting of the S. P. E. E. because he regards this Society as the integrating medium of all engineers, as a center of corrective influence against certain divisional tendencies and because, in his judgment, the S. P. E. E. has consistently favored a broad basic scientific and cultural background for engineers. To make his point of view clear from the start, the writer has always strongly favored the basic engineering training amplified by a more extended training in physics, as the best preparation for the industrial or applied physicist. He also persistently advocates a more extensive opportunity for electives in physics than is usually offered to the engineering student. Furthermore, he believes, like a number of others, that the engineering school should provide this opportunity for training the "physical engineer" or the "engineering physicist." It was because a number of physicists at other institutions had expressed some anxiety about the future of this educational ideal as a result of the E. C. P. D. accrediting that the writer, as chairman of the physics group, decided to invite a continuance of the discussion started last summer at Cambridge by Professor Bidwell of Lehigh.

Perhaps the writer is a foolish Don Quixote tilting educational windmills, but he finds himself irresistibly drawn to a consideration of the primary motives of this E. C. P. D. accrediting movement. Is the movement based on a parallel between engineering

* A paper read before the Physics Conference at the annual meeting of the Society for the Promotion of Engineering Education, at Texas A. & M. College, June 28, 1938.

and medicine or law? Is it motivated by a desire to unify all engineers into a common profession? Is it an attempt to raise the level of engineering education? Or is the motive unconsciously but essentially economic, aimed as much at exclusion as inclusion? I raise these and other questions, without impugning the lofty and noble motives of men like the late General Rees and others who have been most active in its sponsorship.

Nobody need be reminded by me that this E. C. P. D. accrediting looks finally to the licensing of all engineers. Who is an engineer? To press the question farther—Is there such a thing as a general practitioner in engineering like the general practitioner in law or medicine? The sharp insistence upon the distinction between the various kinds of engineers in conformity with the four founder societies is ample rebuttal to the claim that all engineers are alike. To get around this dilemma, the E. C. P. D. found it necessary to recognize the difference by accrediting engineering courses rather than accrediting engineering schools. Who was to do the accrediting? As it worked out in practice, the accrediting of each course was largely under the control of the respective founder societies through their representatives on the local inspection committees. Furthermore, it was the duty of these founder society representatives in assembly, to pass on other phases of engineering and other subjects than the major engineering subjects in which they were recognized authorities.

It is conceded without the slightest reservation that every effort was made to arrive at just judgments. But yet, in spite of all this friendly appreciation and coöperation, I think there are certain possible consequences which are not altogether desirable. These, I now propose to enumerate.

First, I believe the result has been the unconscious setting up of a national norm for each of the main divisions of engineering, which (*a*) does not take sufficient account of differences necessitated by the geographical section in which the school is placed and the economic demands of the community which absorbs its output, and (*b*) gives, in some cases, through its requirements in equipment, an unfair differential to those institutions which can raise money most rapidly.

A second consequence to be looked for is an even greater differentiation between engineers of the future. Placing the accrediting on the course rather than the college may result in intra-competition and may give undue importance to the formation of student branches of the various founder societies who already recruit their membership in some cases as early as the freshman year. Prejudices and loyalties formed this early are seldom outgrown, and I

look for the engineering profession to be more divided in its allegiance than ever before. Furthermore, unless great care is exercised, I would not be surprised to find in the same college, intra-competition between groups, such as between the electrical engineering and physcis, and between mechanical and chemical engineering.

A third consequence which may follow is the exercising by the practicing engineer through his national society of too great an influence on engineering education. This may result in a restriction to normal growth and healthy experimentation in the respective engineering divisions.

A fourth set of consequences may result from calling certain departments "major departments" and other departments "service departments." It would be most lamentable if, in order to maintain supervisory control, each in his respective department, there should result by a sort of senatorial courtesy between the degree-granting departments a sacrosanct attitude that the head of each degree-granting department, or at least the heads of these degree-granting departments combined, carry the undivided responsibility for all useful decisions, not only concerning their own respective subjects but also concerning the sciences in particular and all other "service departments" in general. In my judgment, this would certainly cause several undesirable effects: (1) A departmental insulation which would prevent the free flow of information and advice from certain environmental domains into the engineering fields, domains from which have come in the past, major changes in engineering or even new branches of engineering; (2) An undue distinction in the minds of the students themselves, resulting in a loss of prestige for the so-called "service departments" insulating somewhat individual students against desirable "service department influence"; (3) Prevention of the proper training of those intellectual personalities capable of handling boundary phenomena of two domains of knowledge—personalities whom our civilization often finds most valuable because of their greater elasticity and adaptability; (4) An increase in the technical content of the undergraduate engineering courses at the expense of the scientific and cultural subjects; (5) An extensive movement to replace scientific courses taught by scientists by scientific courses taught by engineers and appearing early in the engineering curriculum under various labels such as "The Elements of Engineering, etc." Unless one is merely trying to train technologists, to deprive the engineering student of a reasonably large access to other types of personality, other domains of knowledge, and other types of thinking than engineering, is to lead him

to unconsciously conclude that the engineering approach and the engineering domain is exclusively the only desirable one. Prejudices of this sort which insulate a student against new ideas outside of engineering would be extremely dangerous to him.

What has all this to do with physics? Simply this, that, like all other so-called service departments, as far as the engineering school is concerned physics may find itself in a defensive position. Just a few supporting statements:

Last year at the annual meeting at Cambridge, a physics professor at a well-known engineering school reported that his course in "Engineering Physics" had been refused accrediting. He also read a letter from a prominent physicist, now an engineering executive, in which it was suggested that should engineering licensing become a primary important specification, the "engineering physicist" or the "applied physicist" might have to look to the American Institute of Physics for economic protection. In some places, I am informed, attempts are being made to modify the engineering physics curriculum to make it acceptable for accrediting.

The unconsciously proprietary attitude of a major branch of engineering for everything that comes under a label has been naively illustrated in several recent courteous proposals which have come to the chairman of the physics committee.

The separatist movement has resulted, according to our information, in the search for more free time for specialist subjects which might be inserted at the expense of physics "service" time.

The separatist movement which places physics in a minor role must also place it on the defensive in securing from the administrative officers of the college sufficient funds for its own development as an independent subject.

The formation of the specified student engineering societies with active student public relations committee and with their recruiting down as far as the freshman year cannot help but spread confusion and decrease the relative importance of physics in the minds of the student, parents, the engineering administrators and the public.

The licensing law with its emphasis on graduation for an engineering curriculum might in the last analysis deprive the physicist of his economic market as a practicing applied scientist.

To summarize, it seems to me that the impacts of the E. C. P. D. on physics operate, not so much to promote this domain, but unintentionally to impede the physics department in its attempt to discharge its full economic and intellectual responsibilities under the engineering flag.

What can be done about it? I believe in the law of compen-

sation. The critical factor in the situation is the passage of the Engineering Licensing Law.

Since engineering is essentially not a set of personal individual businesses like law or medicine, but seeks a market which involves larger economic units of men, material, and money, it is my judgment, that industry, which absorbs most of the engineering graduates, will not permit the passage of an unfair licensing law which unduly taxes industry for the benefit of a few consulting engineers.

Furthermore, the community which needs the services of the scientists as well as the engineers will not stand for laws which deprive it of these services except when an additional tax is paid professional engineers who merely market this knowledge and technique without adding essentially anything to them.

An engineering movement which concerns educational matters without satisfactory consideration for the variation in necessities of the various communities which it is designed to serve, will correct itself by opening the way for another compensatory educational agency.

Engineering education which is too specialized turns out men specialized for jobs of which there may be only a few vacancies. The head of an engineering department who is unable to place his graduates in industry will find himself faced with an irrefutable argument.

A movement which emphasizes too highly the differential between the various types of engineers will produce an intracompetition between the various branches equal to that between engineers and scientists, and engineers and architects. A divided profession means a series of minor professions.

Maybe this is the cue. Perhaps the physicist should accept this position and fly his own separate flag. What do you think?

Twenty-five years happy association with engineering and engineers does do something to one; nobody likes crossroads where friends divide. Nobody likes to give up dreams and the writer has always dreamed of a very close association between science and engineering, not in the relationship of master to vassal, but as two co-equals each contributing irreplaceably in its own right.

SPECIFICATION OF AN APPLIED GEOPHYSICIST*

By J. C. KARCHER, Geophysicist, Dallas, Texas

My specification for the education of a student who wishes to enter the field of applied geophysics is a relatively simple one. It consists of two elements: First, he should be properly grounded in the fundamental subjects which are essential to his endeavor; and second, he should be so trained that he will realize the economic significance of his endeavors.

In the matter of the first requirement, in my opinion, there is no essential difference between this preparation and that which he would require if he were entering the academic or research field, so far as undergraduate studies are concerned, because, most certainly thorough ground work is more important than all the special work that a student can hope to do in the usual four year college course.

I believe that the average student, before or shortly after entering college, should not contemplate a limited field of endeavor for his work, because there are so many diversions that may develop in the course of his life and he may subsequently regret the fact that he did specialize in his college work. A student should, on the other hand, so arrange his college work that he may contemplate a large part of the industrial field and prepare himself in such a manner that he can divert his efforts in other directions as opportunities arise which justify such diversions.

Consequently, if a student expects to enter the field of geophysics, I recommend that he prepare himself thoroughly in the fundamentals of physics and mathematics, geology and chemistry. I would require that he complete all the pre-requisites to differential and integral calculus, as well as those subjects, and also differential and partial differential equations. He should complete his first general course in physics, preferably taught as a second year subject, with a knowledge of calculus. I would consider a first year's course in physics given before the student is able to use his calculus as an unsatisfactory course. The second year general course in physics should be supplemented with an advanced course in electricity and magnetism, preferably as a full year course, also advanced courses in mechanics, thermodynamics and optics. He

* Presented at the Conference on Physics at the 46th Annual Meeting, S. P. E. E., College Station, Texas, June 27–30, 1938.

should have two years of geology and one and a half years of chemistry including quantitative analysis. As to any additional courses in physics, it would be wholly a matter of choice; but I would not consider any specialized courses of particular value. The above requirements are little different from those I would suggest for a student who wishes to enter the field of research physics, or as a worker in the academic field, except that the academic or research worker should have graduate training.

However, it is at this point that I would introduce a sharp differentiation between the training for the petroleum geophysicist and research physicist, and for this reason. The petroleum geophysicist undertakes an adventure which is primarily intended to be profitable with respect to time, effort and money expended. Therefore, his point of view must be governed by these requirements:

It is necessary that the element of time be always kept in mind, and that he conduct his work efficiently and economically in order that he may show a profitable return upon his endeavors and the expenditures connected therewith. If the industrial worker cannot show a profit in his adventure, he cannot justify his endeavor.

Because of these requirements it is desirable to develop in the student an engineering point of view; and I believe this is done in a great measure by the manner in which he is taught his various scientific subjects. For instance, his laboratory work might be assigned to him with a definite time limit for its completion and for preparation of his report. Perhaps his grade in the work should be influenced by the rapidity with which he can accomplish his experiments. In many instances in the industrial research field, if work is done rapidly it may be profitable, whereas the same endeavor if accomplished in fifty per cent more time may prove to be a loss as a financial undertaking. Purely research work does not have such requirements because of the difficulty in estimating the value of these endeavors.

A very important and valuable attainment on the part of the student is to develop the ability for obtaining quickly a physical concept of mathematical equations in order that he may be able to anticipate and predict the results of his efforts (which are desirable in order to guide his endeavors) without the necessity of spending time in elaborate mathematical calculations to arrive at these same conclusions.

Furthermore, he should have a small personal equation, which implies that he should not be inclined to jump at conclusions or let his own wishes affect them.

Coming more specifically to the training of a geophysicist, I would recommend that he prepare himself in the fundamental sub-

jects as I have first set forth; and that he either be taught these subjects in a manner to develop an engineering point of view of expediency and efficiency, or that he take engineering subjects appropriate or associated with his interests in order that he may develop this engineering point of view.

Suitable courses in mechanical, electrical and petroleum engineering may be taken which will be valuable to him, both as a matter of training and preparation for entering these broader fields in the event in later years he finds opportunities in these fields.

In conclusion I might state my specification for a geophysicist in one sentence by saying, he should have a thorough knowledge and training in the basic sciences of mathematics, physics and chemistry, and the associated science of geology; and he should have an engineering point of view.

RECENT DEVELOPMENTS IN CHEMICAL ENGINEERING EDUCATION IN EUROPE*

By E. E. RANDOLPH

Professor of Chemical Engineering, North Carolina State College

The facts which form the basis of this paper were obtained by attendance at the World Congress of Chemical Engineers in London in 1936, by a visit to some of the universities and technical schools and chemical industries in England and in some of the European countries, and also from publications of the institutions. At the World Congress of Chemical Engineers reports were made on chemical engineering education by representatives from several countries.

Chemical industries in the United States have developed more rapidly during the past thirty years than they have perhaps in any other part of the world. This fact has probably caused the rapid crystallization of a more fixed form of chemical engineering training in this country than exists in other countries. Other factors also have contributed to the readiness of American institutions to attempt newer forms of education than we find in the older countries.

In this country traditions influence our action and customs to a less degree than they do in European countries. America is a comparatively young country settled by pioneers. Throughout a short history the pioneer spirit has been predominant. Our people are accustomed to expect rapid changes and developments in all phases of our activity and experience. The country is yet too young to have a strong feeling of reverence for the past.

A different situation exists in Europe. The countries and civilization are comparatively old. The traditional atmosphere permeates the educational system of England and of some of the European countries. An educational system has grown up which has become fixed and fundamental. The traditional idea has developed that the university exists for the development of thought for thought's sake and to encourage students to study for the love of learning. Emphasis on the love of learning idea possibly created the impression that it was undignified and unacademic to teach students anything which would enable them to earn a living in an

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industrial position. The older universities have not been quick to include in their curricula engineering studies, which fact made it necessary to develop technical schools for practical training. Only in recent years Oxford University established training in electrical, civil and mechanical engineering. The Hochschule in Germany corresponds to the English technical schools. A distinction, therefore, grew up between the university with its academic type of training and the technical institutions which gave the practical engineering type of training. It may be somewhat unfortunate that the universities were too high brow to teach practical education because their cultural facilities and historical background would probably lend prestige to the training of the engineering students.

It should be recognized that chemical engineering training in the educational institution grows out of the need for men with specialized training in the chemical industries. The original branch of engineering probably was of military origin to enable a certain branch of the Army to do the road and bridge construction and to aid in the campaign outline for the Army. In time of peace a corresponding branch of engineering to develop roads, bridges and construct dams and buildings called for trained civil engineers. Later times called for mechanical and electrical engineers to engage in specialized branches of engineering work. The association of men in crafts or guilds perhaps developed later into such organizations as Institution of Mechanical Engineers and the Institution of Electrical Engineers. Chemical engineering developed as a separate division of general engineering because of the particular requirements in the equipment needed and in the processes used in such practical work as salt making, sugar boiling, and distillation. The Institution of Civil Engineers was founded in England in 1818. It was not until the last quarter of the 19th century that a definite branch of applied science was necessary in the development of the heavy chemicals on a large scale. Chemical engineering, therefore, was developed for the particular needs of a type of industry and not as an outgrowth of some existing engineering scheme.

Two factors in England have been influential in initiating instruction in chemical engineering. These two factors are the needs of chemical industries, and the specification for educational training suggested by the Institution of Chemical Engineers which works for the interest of technical chemical engineers and in the interest of chemical industries.

In different countries various ideas exist as to the fundamental background for their chemical engineering training. The Institution of Chemical Engineers of England considers chemical engi-

neering as a branch of applied physics. For example, it believes that chemical engineering is more definitely concerned with the application of physics than even with the application of chemistry, as in the consideration of such matters as the transportation of solids, flow of fluids, mixing and agitation, crushing and grinding, and heat transfer, and even in distillation, filtration, and evaporation. They do not, of course, ignore the necessity of a proper background in mathematics and in chemistry. The first training in chemical engineering in England seems to have been inaugurated in a series of lectures in the Manchester Technical School in 1887 in which the idea of particular plant design and processes of chemical industries were emphasized in a more or less descriptive way.

The rapid growth of chemical manufacturing work during and immediately following the World War developed the conscious need of definite training in the technical schools of England. Closely associated with the British Institution of Chemical Engineers is the Society for Chemical Industries which was founded in 1918. These groups have proposed to the technical institutions of England definite courses of study. They are using these outlines of courses as a basis for membership in the societies, which membership is a strong recommendation to the industries for the acceptance and employment of their members for technical work in the large industries. The number of institutions in England, however, which have accepted the curriculum as proposed is small. So far as I have learned Loughborough College only gives an integrated course as proposed.

Chemical Engineering in Kings College, University of London

The course consists of one year post graduate work following a four year course and B.S. degree either in chemistry or in engineering each having required good training in chemistry, physics and mathematics. The nature of the work is varied according to the previous training. The object is to supply the basic training in either chemistry or in fundamental engineering depending on the student's previous undergraduate training and to teach the scientific principles underlying the methods of carrying out chemical processes on a commercial scale.

For this purpose close coöperation exists between the departments of chemistry and of engineering. The previous chemistry students are instructed in engineering drawing, materials of construction testing, production and transmission of mechanical and electrical energy; and the former engineering students are in-

structed in suitable branches of advanced chemistry. The common training of both groups deals with chemical engineering operations and processes, plant construction, energy requirements and efficiency of operations, design of plants, quantitative flow-sheets, costs, location and layout of works. Emphasis is given to laboratory and workshop practice and on industrial problems studied practically in plants. Further research leading to the M.Sc. or Ph.D. degree is encouraged.

The public examination for the B.S. degree in chemical engineering consists of materials of construction, design, mechanics of fluids, theory of machines, heat engines, electrical technology,

LOUGHBOROUGH COLLEGE

CHEMICAL ENGINEERING CURRICULUM

First Year

Math.
Applied Math.
Drawing and Design
Physics
Chemistry
Applied Electricity
Workshop Processes
Physical Training
Chem. Eng. Lecture

Second Year

Math.
Applied Math.
Eng. Drawing and Design
Physics
Chemistry
Applied Electricity
Workshop Processes
Industrial Administration
Physical Training
Chem. Eng. Lecture

Third Year

Math.
Physics
Organic Chemistry
Inorganic Chemistry
Chemical Analysis
German
French
Chemical Laboratory
Geology
Strength of Materials
Metallurgy
Economics
Applied Electricity

Fourth Year

Organic Chemistry
Inorganic Chemistry
Physical Chemistry
Chemical Analysis
German
French
Chemical Laboratory
Machine Design
Strength of Materials
Metallurgy
Economics
Applied Electricity

Fifth Year

Chemical Engineering Calculations
Metallurgy
Industrial Management
Chemical Engineering Processes
Chemical Plant Construction and Materials
Factory Design and Operation
Works Practice in Productive Chemical Works of Department

theoretical, organic, inorganic and physical chemistry, chemical engineering operations and processes, management of chemical works, design and layout of chemical plants. After such an examination and two years practical experience graduates are admitted to Associate Membership of the Institution of Chemical Engineers.

Other institutions giving similar courses in Great Britain are: College of Technology of Manchester, Royal Technical College of Glasgow, Battersea Polytechnic Institute, London.

Loughborough College, Leicestershire, a young engineering school, offers an integrated five year plan of chemical engineering training somewhat similar to the kind of training given in an American institution. This young engineering college is located at the center of the great chemical industry of England.

Special fundamental chemical engineering subjects studied include: Production, utilization, and transfer of heat, design of furnaces and steam production, electrical generation, gaseous fuels, fluid flow, conveyance and storage of materials, control of process variables, disintegration, separation, extraction, filtration, evaporation, distillation, crystallization, dusts, fogs, drying, calcining, refrigeration, electrochemical operations, catalysis, organic processes, plant construction, design and suitable materials, plant layout, and organization of works, testing of materials.

The curriculum for chemical technology differs from that in chemical engineering principally in emphasizing processes of manufacture and in omitting largely special studies in design and in unit operations according to the following outline:

First and Second Years	*Third and Fourth Years*
Mathematics	Mathematics
Physics	Engineering Drawing
Chemistry (Theoretical and Analytical)	Physics
English, French German	Chemistry (Organic, Physical, Practical)
Mechanics	German, French
	Geology
	Applied Electricity

Fifth year postgraduate work may include special study of a process industry. The four year chemical technology, or applied chemistry course in this institution does not include studies of specialized industries as options, as is the case in the other technical institutions of England and of Europe generally. In the fifth year of both chemical engineering and chemical technology courses a special course in petroleum technology is provided. The chemical engineering students during the fifth year work through the

semi plant scale division in which chemical products are made on a productive basis.

In the Royal Technical College of Glasgow the Chair of Natural Philosophy and Chemistry was established in 1796. In 1830 they were divided into separate departments, and the chair of Technical Chemistry was established in 1870.

The chemical engineering curriculum consists of two parts of two years each. Part one is fundamental engineering studies and part two is largely technical chemistry and design.

First Year	*Second Year*
Natural Philosophy	Mathematics
Mathematics	Heat Engines
Chemistry	Elec. Engineering
Engineering Drawing	Mechanics
	Eng. Drawing
	Eng. Laboratory

This part leads to the first examination.

Part two consisting of the third and fourth years work leads to the degree of diploma.

Third Year	*Fourth Year*
Mechanics and laboratory	Eng. Production
Heat Engines and laboratory	Metallurgy
Technical Chemistry and laboratory	Technical Chemistry and laboratory
Natural Philosophy	Elec. Engineering
Eng. Drawing and Design	Chemical Engineering Design
	Engineering Materials
	Hydraulics

Specialization is reserved for the fourth year during which four considerations are emphasized: Materials of construction, fuels and their applications, the operations of chemical industry, and chemical engineering design. The technical chemistry work parallels and furnishes practical work for the fourth year in which the principles underlying the manufacturing operations of various industries are studied. Sufficiently large scale experiments are carried out in the laboratories to obtain an insight into industrial methods, costs, and economical production. Special options for students wishing to specialize in certain industries are provided in the technical chemistry division in such work as sugar manufacturing, dyes and their applications, oils and fats, coal tar and its products.

The curriculum in technical chemistry in Sir John Case Institute affiliated with the University of London consists of a chemistry curriculum largely with technical chemical options in specialized studies in fermentation industries, petroleum and fuel

technology. The curriculum in chemical engineering consists of fundamental engineering courses during the first year, of design and construction of chemical plants during the second year, third, and fourth years supplemented by fuels, engineering materials, shop practice with general theoretical chemical courses.

In the Municipal College of Technology of Manchester the courses leading to a degree in applied chemistry are general chemical technology, metallurgy and assaying, fermentation processes, electrochemistry, dyes, fuels, paper manufacture, and a course in chemical engineering. The intermediate examination at the end of the second year includes besides chemistry and chemical technology, mathematics, physics, engineering, and a foreign language, and the elements of chemical engineering. The work of the second part includes theoretical chemistry courses, design, heat engines, heat transmission, hydraulics, the technical courses mentioned above and materials.

Review of Chemical Engineering Training in Germany

In the plan of higher education in Germany the universities have traditionally trained their students in the cultural and scientific branches and the Hochschule, or technical institutions, have specialized in engineering and technical training.

Because of the great development of chemical industries and of its former export trade Germany had built up the need for properly trained chemical engineers. Even though the German chemical industries have developed remarkably, only relatively few students have been trained as chemical engineers. Somewhat romantic is the history of the development and success of early German chemical manufacture largely as an outgrowth of the fundamental research of some of the world famous chemists who have done much to find the nature of the structure of organic molecules and methods for important conversion products. During the latter part of the past and the first part of the present century German industries produced much of the dyes and pharmaceutical preparations. The success of these developments was due largely to the painstaking work for new chemical formulas and processes. Consequently a thorough knowledge of organic chemistry was necessary. Standards of the first rank in the best possible scientific training in chemistry were maintained in the institutes of technology and universities.

In the field of building apparatus and chemical equipment construction German industries were also successful. As long as the production was comparatively small no great demand existed for men trained in chemical engineering, but when requirements for equipment on a large scale and at lower prices became pressing

men with practical, as well as scientific training, became more and more necessary. In the early stages of the manufacturing of dyes and apparatus, competition was not keen and comparatively small quantities of various products were demanded. Consumers began to require larger amounts, better qualities, and lower prices for their products. About the beginning of the present century the production of new inorganic substances came into prominence. The process for production required high temperatures, and more recently high pressures, so that greater demands were made on the builders of equipment than the older type of organic chemical industries required. The problem of meeting the technical requirement of chemical machinery could no longer be met by pure chemists. Along with the developments in newer types of equipment came the necessity for men properly trained in the problems of operation and control work. The needs of the chemical industries determine the demand for chemical engineers, and hence the kind of training expected for these men. It has therefore been the cooperation of the industries with the technical institutions of Germany which have produced the present plan of chemical engineering education. The Society of German Engineers, doubtless, has not been as strong a factor in attempting to control the type of education in the institutions as has been the case with the British Institution of Chemical Engineers or with the American Institute of Chemical Engineers. The types of chemical industries may be classified as the large chemical industries, the small chemical industries, the plant manufacturers and builders, and works manufacturing materials for the chemical trade. The plan has been to coördinate the work of the technical chemist with the work of the mechanical engineer in the large plants. According to the German system this coöperation seems to have been reasonably successful; however, the chemical industries have found that men especially trained also are needed in their employment.

According to the German conception the chemical engineering training is of a double nature. In one case the *chemical engineer* is understood as being a man who is in the first place an engineer with a later chemical training. The *engineer chemist* is a man with a primary training in chemistry and later with an engineering training. The chemical engineering training in the German technical institutions is divided into two periods; the first two years leads to a State examination known as the Vorexamen; and the second two years leads to the diploma-hauptexamen. The conception of chemical engineering seems to concern a sphere between chemistry and engineering training. The first two years are divided largely into theoretical and experimental fundamentals and the second two years to technical applications.

A knowledge of machine design and construction is regarded as fundamental. This training along with physical chemistry takes place in the second period. This new type of chemical engineering training was inaugurated at Karlsruhe. The types of chemical training in some of the important technical institutions are given in the following table contained in a report on German chemical engineering education given by Professor A. Eucken at the Congress of Chemical Engineers in London 1936.

The apparent successful plan of training is for fundamental courses and special chemistry training up to the first State examination followed by training in the design and research and study of chemical equipment along with a study of physics and physical chemistry. The tendency whenever possible is to follow this training up to the Doctor of Engineering degree with research and a dissertation and systematic instruction in the principles of chemical engineering. The advantage of this type of training seems to be that there is time given for each phase of the training so that each principle is mastered in every respect. A background of each case is formed also for the subsequent studies and the student is provided thereby with the capacity which is useful to him in each new sphere of activity. This type of systematic instruction together with the practical experience in building laboratory equipment has proven useful. During the period for the doctorate the candidate listens to prepared lectures, takes part in colloquiums, engages as an assistant in classes and in experimental demonstration work.

It is interesting to note that the large chemical industries still maintain their force of thoroughly trained theoretical chemists for special research work and their force of mechanical engineers to maintain mechanical equipment. Although to a limited extent some of the institutions have undertaken to train men for particular industries such as the refrigeration industry phase of chemical engineering, this practice has not generally been attempted. They seem to prefer an engineer with a general fundamental chemical engineering training to one with a narrower type of training. As a rule, however, the institutions provide training for various types of chemical manufacturing by short elective courses. Such elective courses concern such manufacturing operations as cellulose, leather, fiber, fats and oil. The system includes fundamental mathematical training so that the research and practical work is done on the quantitative basis. Thermodynamics, and electrochemical courses are given in a thorough manner. Provision is made in general lectures to give instruction in the control of the processes for obtaining approved quality of material. Emphasis is constantly placed on thorough training in physical chemistry and

SURVEY OF THE PRESENT NATURE OF THE CHEMICAL ENGINEERING TRAINING IN THE TECHNICAL INSTITUTIONS OF GERMANY

Institution	General Training of the Chemical Engineer According to an Approved Plan. Diploma Examination *	Systematic Training of Chemical Engineers in a Special (Branch of Knowledge). Diploma Examination	Incidental (Occasional), not Planned, Training of a Chemical Engineer. Laying down the Diploma Examination in the Profession	
			a. Doctorate	*b.* Profession
Aachen		Metallurgy	Machine Building. Metallurgy, Science of Mining	Textile Chemists Fuel Chemists Capillary
Brannschweig			Machine Building	Chemical Technology
Breslau	Special plan of institution (in the year 1924–30) for industrial chemists up to the preliminary examination (Vorexamen): Org. Chem., Phys. Chem., Math., Physics Fundamentals of Machine Building. After the Vor examination, elementary, technical, professional (chemical technology, electroch. machine building, etc.)	Metallurgy	Machine Building	Physical Chemistry
Danzig	Arrangement of a plan of instruction for chemical engineers similar to that already existing in Karlsruhe is planned		Machine Building	Inorganic and Physical Chemistry
Darmstadt		Cellulose (paper) Chemistry	Machine Building	Chemical Technology
Dresden	Special plan of instruction for chemical engineers. Vor examination as in Chemistry. Required courses in the High examination: Phys. Chem., General Electrochemistry, Outlines of Heating Apparatus Control, besides two optional courses. In the earlier years a study plan for manufacturing chemists similar to that of the Breslau plan of study)	Textile Chemistry Paper Chemistry		
Karlsruhe	Since 1928 special study plan for chemical engineers. Preliminary examination as for mechanical engineers and additionally a small Inorganic Chem. course. Required courses in the chief examination; Apparatus Building, Chemical Technique, Phys. Chem., Technical Thermodynamics, Heating Machinery, Economics and 2 or 3 electives	Refrigeration Gas Engineering		

* The diploma examination of technical institutions in Germany is divided into two parts: the Vorexamen after 4–5 semesters' study and the Hauptexamen after 3–4 more semesters' study. The so-called theme occupies a considerable part of the latter part, for the discharge of which a period of 2–3 months provided for and for the chemists the nature of the work is mostly experimental, for mechanical engineers mostly constructive. By the machine engineers a year's practical work for admission to the diploma examination is required, by the chemist not required.

machine control. The fact is recognized that whenever it is possible for the chemical engineer to continue to the degree of Doctor of Engineering he increases his ability to solve industrial research problems with assurance, and also that this very ability will eventually lead him to more certain and more rapid promotion. Because of these economic factors the tendency is for an increased number of applicants for the Doctor's degree.

Chemical Engineering Education in Austria

Provision has been made in institutes of technology of Austria for 75 or 80 years for teaching civil, electrical, and mechanical engineering, since the foundation of the institutes. The plan of study was that a period should be spent in the fundamental scientific field. This period was closed by the first State examination. Specialized engineering training followed. The professors are men engaged in industry. Industrial chemists are trained in a slightly different way. At first scientific chemistry is studied. Then the particular application of it in the special industries is worked out in class work. In Germany on the other hand the large industries were developed by theoretical chemists working in coöperation with mechanical engineers. It was the small chemical industries which could not afford to have both a corps of theoretical chemists and of separate engineers who asked the institutes to give technical training to the chemists. This was the beginning of a type of special chemical engineering training.

In the Technische Hochschule of Vienna after the first period of scientific training and examination the purely technical course of study is divided into two options: in one industrial or technical chemistry is taught; in the other fuel engineering and machine and plant construction are studied. The curriculum includes: First year of scientific period; mineralogy, mathematics, chemistry, ore deposits, mechanics, organic chemistry, analytical chemistry, botany; the second year includes organic chemistry, physics, machinery, drawing, laboratory work in chemistry. In all of the courses intensive laboratory work is required. The work of the first year of the technical period includes technical electricity, economics, electrochemistry, industrial chemistry, physical chemistry, microscopy, enzymology. The work of the second year is entirely a technical study of the production of the various chemical products commercially. The option in fuel technology consists of practically the same courses except that emphasis is placed on fuels, furnaces, heating and steam boilers more than on the special chemical manufacturing work. In both cases constant and exhaustive laboratory work is required and also a piece of research

work covering a period of three months is specified on which a satisfactory thesis must be prepared before the final State diploma examination is given.

Instruction in the Institutes of Chemistry is for young people who desire thorough theoretical and practical training for industrial careers or for scientific work.

The course covers three years based on a course of chemistry of the Faculty of Sciences but is completed by a group of conferences and practical work of a second three years. The two last years course consists of: Practical work in mineral (inorganic) chemistry, physics laboratory, organic analysis and synthesis, inorganic analysis and research, industrial chemistry, and electrochemistry. Complimentary courses are in mathematics and physics, mechanics and technological engineering. At the end of the course the student receives the degree of Engineer Chemist. The best students are admitted to research, scientific and practical, toward the doctorate in engineering.

Switzerland

All Swiss universities have their chemical institutes which provide both theoretical and practical training in chemistry. The practical training at these universities is somewhat of the nature of industrial chemistry or of chemical technology. The principal universities giving such instruction are Zurich, Basle, Bern, Geneva, Lausanne, Fribourg and Neuchatel.

More strictly chemical engineering instruction is given in the technical institutes, principal of which is the Technische Hochschule of Zurich. The instruction is much like that given in the German Hoschschule.

In general, to the European universities we owe much for their splendid work during the past century and a quarter in working out the basic scientific knowledge of chemical nature of matter, the constitution of matter, the fundamental concepts of chemical reactions and the basic laws of chemistry. This work was done in a most thorough manner. The background of such scientific work leaves its mark on the present emphasis on fundamental training in chemistry with perhaps a less emphasis to a degree on the distinctly engineering phase of chemical engineering training than is found in the curricula in the institutions of the United States.

NEW MEMBERS

ARENSON, SAUL B., Professor of Chemistry, University of Cincinnati, Cincinnati, Ohio. Herman Schneider, C. W. Park.

BOLZ, HAROLD A., Instructor in Machine Design, Purdue University, Lafayette, Ind. A. A. Potter, W. J. Cope.

BORGMANN, CARL W., Professor and Head, Department of Chemical Engineering, University of Colorado, Boulder, Colo. H. S. Evans, W. O. Birk.

CARTLAND, FRED W., Assistant Professor of Electrical Engineering, Michigan College of Mines and Technology, Houghton, Mich. G. W. Swenson, F. E. Johnson.

CHAMBERS, ALVIN L., Assistant Professor of Testing Materials, University of Kentucky, Lexington, Ky. E. A. Bureau, D. V. Terrell.

CHRISTENSEN, N. A., Dean of Engineering, Colorado State College, Fort Collins, Colo. J. T. Strate, H. G. Jordan.

COLLARD, ARTHUR A., Instructor in Mechanical Laboratory, Pratt Institute, Brooklyn, N. Y. C. C. Tyrell, F. S. Egilsrud.

CURTIS, HARRY A., Dean of Engineering, University of Missouri, Columbia, Missouri. R. W. Selvidge, A. C. Lanier.

DUNCAN, DONALD S., Instructor in Mathematics, Pratt Institute Brooklyn, N. Y. W. H. H. Cowles, H. C. Hostetter.

EDMONSON, NAT. JR., Professor of Mathematics, A. & M., College of Texas, College Station, Texas. M. C. Hughes, N. F. Rode.

FRIEDRICH, LAWRENCE, Instructor of Civil Engineering, University of Toledo, Toledo, Ohio. D. M. Palmer, H. O. Huss.

GOFF, JOHN A., Dean, Towne Scientific School, University of Pennsylvania, Philadelphia, Pa. M. L. Enger, N. Krase.

GREENWALD, D. U., Instructor in Mechanical Engineering, University of Delaware, Newark, Del. R. L. Spencer, J. L. Coyle.

GUNDER, D. F., Assistant Professor of Mathematics, Colorado State College, Fort Collins, Colo. H. J. Gilkey, S. L. Macdonald.

GURNHAM, CHARLES F., Instructor in Chemical Engineering, Pratt Institute, Brooklyn, N. Y. Tod G. Dixon, J. S. Egilsrud.

HEDBERG, JOHN, Assistant Professor of Civil Engineering, Stanford University Stanford University, Cal. Eugene L. Grant, Arthur B. Domoneske.

HOLCOMB, ROBERT M., Instructor in Civil Engineering, University of Arizona, Tucson, Ariz. John Park, G. M. Butler.

HOTTLE, WARREN M., Instructor in Physics, Pratt Institute, Brooklyn, N. Y. Emerson P. Lambe A. W. Doll.

HOUSTON, HARRY H., Instructor in Chemical Engineering, Pratt Institute, Brooklyn, N. Y. R. H. Wing, G. F. Kinney, Tod F. Dixon.

KIPP, HAROLD L., Associate Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas. O. V. Adams, H. F. Godeke.

LANGSNER, ADOLPH, Chief Engineer and General Superintendent, Eugene Dietzgen Company, Chicago, Ill. E. W. Carlton, Henry P. Dutton.

MAY, JAMES W., Associate Professor of Heating and Ventilation, University of Kentucky, Lexington, Ky. C. C. Jett, W. E. Freeman.

MILLER, EDWARD C., Instructor in Metallurgical Engineering, Purdue University, Lafayette, Ind. A. A. Potter, J. L. Bray.

MOODY, HOWARD M., Dean, College of Engineering and Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. F. L. Bishop, Nell McKenry.

MOORE, MARK B., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. J. S. Egilsurd, C. C. Tyrrell.

OLESON, CALVIN C., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, S. D. H. B. Blodgett, H. M. Crothers.

PETRIE, GEORGE W., Assistant Professor of Mathematics, South Dakota State School of Mines, Rapid City, S. D. Carl G. Watson, E. E. Clark.

PUGH, EMERSON M., Associate Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa. Charles B. Stanton, W. N. Jones.

ROHLICH, GERARD A., Instructor in Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. M. McCullough, Harold A. Thomas.

SCHULTE, WILLIAM C., Assistant Professor of Mechanical Engineering, Rutgers University, New Brunswick, N. J. P. H. Daggett, Neil P. Bailey.

SHREEVE, CHARLES A., JR., Instructor in Industrial and Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. R. B. Dale, W. H. H. Cowles.

SIDLE, ROBERT G., Instructor Physical Elements of Engineering, Pratt Institute, Brooklyn, N. Y. Alfred W. Doll, Harry P. Schmidt.

SMALL, ERIC H., Instructor in Mechanical Engineering, University of Toledo, Toledo, Ohio. D. M. Palmer, I. F. Zarobsky.

SOUCEK, EDWARD, Assistant Professor of Civil Engineering, University of Toledo, Toledo, Ohio. D. M. Palmer, Harry O. Huss.

STEPHAN, ERICH R., Instructor in Mechanical Engineering, Tulane University, New Orleans, La. James M. Robert, Arthur M. Hill.

STILES, WILLIAM B., Instructor in Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. H. J. Gilkey, S. J. Chamberlin.

STROHM, RUFUS T., Dean of the Faculty, International Correspondence Schools, Scranton, Pa. Samuel Baker, G. W. Farnham.

THOMAS, WILLIAM A., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Iowa. H. W. Anderson, M. S. Coover.

VANDER VELDE, THEODORE L., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. G. P. Stocker, R. O. Wray.

VELZ, CLARENCE J., Professor of Sanitary Engineering and Head, Dept. of Civil Engineering, Manhattan College, New York City. Amandus Leo, D. J. O'Connell.

WALKER, LESLIE A., Assistant Professor of Aeronautical Engineering, University of Alabama, University, Ala. G. J. Davis, Jr., F. R. Maxwell.

83 new members

COMMITTEES FOR 1938–39

Conferences: George W. Case, University of New Hampshire, Durham, N. H., will be in charge of all conferences for the 47th annual meeting to be held at Pennsylvania State College, State College, Pa., June 19–23, 1939.

Executive: Karl T. Compton, Chairman, Massachusetts Institute of Technology, Cambridge, Mass.; George W. Case, M. L. Enger, F. L. Bishop, and W. O. Wiley.

Publication: F. L. Bishop, Chairman, University of Pittsburgh, Pittsburgh, Pa., K. T. Compton, and S. B. Earle.

Program: K. T. Compton, Chairman, George W. Case, M. L. Enger, W. O. Wiley, and F. L. Bishop.

Institutional Members: R. A. Seaton, Chairman, Kansas State College, Manhattan, Kansas; D. C. Jackson and R. L. Sackett.

Relations with Engineering Societies: H. P. Hammond, Chairman, Pennsylvania State College, State College, Pa.; H. J. Gilkey, D. C. Jackson and F. L. Bishop.

Engineering Economy: Eugene L. Grant, Chairman, Stanford University, Stanford University, Calif.; E. D. Ayres, J. C. Clark, F. H. Crabtree, Hugo Diemer, W. D. Ennis, L. R. Guild, Scott B. Lilly, A. I. Peterson, B. M. Woods.

Engineering Research: F. T. Mavis, Chairman, University of Iowa, Iowa City, Ia.; B. R. Van Leer, O. G. C. Dahl, E. R. Weidlein, E. Weber, H. J. Gilkey, R. C. Ernst, W. E. Milligan, L. G. Straub and J. H. Weaver.

Labor Relations: H. P. Hammond, M. M. Boring, E. M. Stephens.

Professional Status and Employment of Engineering Graduates: John R. Bangs, Jr., Chairman, Cornell University, Ithaca, N. Y.; L. M. K. Boelter, M. M. Boring, C. E. Bullinger, P. H. Daggett, Howard L. Davis, O. W. Eshbach, O. A. Leutwiler, F. A. Magoun, J. E. McDaniel, and E. M. Stephens.

Comprehensive Examinations: R. L. Sackett, Chairman Pennsylvania State College, State College, Pa.; C. V. Mann, Paul Cloke, R. H. Frazier, C. T. Olmsted and Justus Rising.

Junior Colleges: W. E. Wickenden, Chairman, Case School of Applied Science, Cleveland, Ohio; E. B. Norris, F. C. Bolton, H. C. Sadler, H. B. Dirks, R. A. White, A. H. Gehrig, C. A. Anderson and F. O. Rose.

English: E. C. Elliott, Chairman, Purdue University, Lafayette, Ind.; H. L. Creek, K. O. Thompson, John Mills, W. O. Sypherd, J. L. Vaughan, A. M. Greene, O. J. Ferguson, John G. Bowman and H. S. Rogers.

Industrial Engineering: C. E. Bullinger, Chairman, Pennsylvania State College, State College, Pa.; C. W. Beese, G. W. Barnwell, A. P. Alford, H. G. Thuesen, A. S. Knowles, J. R. Bangs, Jr.

Orientation of Freshmen: A. R. Cullimore, Chairman, Newark College of Engineering, Newark, N. J.; Paul Cloke, W. E. Duckering, H. B. Luther, F. Ellis Johnson, E. J. Streubel, Bradley Stoughton, B. R. Van Leer and O. S. Zelner.

Instructional Methods: H. L. Dodge, Chairman, University of Oklahoma, Norman, Okla.; C. S. Ell, L. F. Rader, A. D. Moore, R. P. Baker and R. L. Spencer.

Physics: G. E. Grantham, Chairman, Cornell University, Ithaca, N. Y.; D.

S. Elliott, W. L. Severinghaus, O. M. Stewart, N. E. Wheeler, C. G. Watson, F. G. Slack, H. S. Hower and H. I. Tarpley.

Sections and Branches: G. W. Case, Chairman, University of New Hampshire, Durham, N. H.; L. W. Hitchcock, R. W. Morton, H. W. Bibber, J. M. Robert, F. O. Rose and F. M. Warner.

Progress: C. F. Scott, Chairman, Yale University, New Haven, Conn.; C. C. Williams, H. A. Curtis, J. A. Goff, H. W. Bibber.

Lamme Award: E. B. Roberts, Chairman, Westinghouse E. & M. Company, East Pittsburgh, Pa.; for four years, F. C. Bolton, A. & M. College of Texas, C. E. Bullinger, Pennsylvania State College, F. L. Plummer, Case School of Applied Science; for three years, D. C. Jackson, 5 Mercer Circle, Boston, Mass., R. C. Ernst, University of Louisville, H. B. Langille, University of California; for two years, G. W. Case, University of New Hampshire, R. E. Freeman, University of Kentucky, H. S. Evans, University of Colorado; for one year, E. B. Roberts, George B. Thomas, 463 West Street, New York City, Frederick Bass, University of Minnesota.

Membership: K. T. Compton, Chairman; C. R. Hixon, J. R. Cudworth, W. R. Spencer, B. M. Woods, A. C. Terrill, W. H. Austin, D. B. Pheley, A. G. Gehrig, H. H. Bliss, F. Paulsen, F. Bailey, F. W. Rose, F. H. Sexton, W. E. Lovell, J. M. Turnbull, S. W. Dudley, T. D. Mylrea, L. K. Downing, N. C. Ebaugh, R. C. Brinker, J. B. Finnegan, W. C. Bauer, A. A. Potter, D. B. Prentice, E. L. Waterman, L. E. Conrad, R. C. Ernst, J. M. Robert, S. S. Steinberg, C. E. Tucker, M. S. Munro, H. H. Higbie, A. R. Carr, G. W. Swenson, L. L. Patterson, Harry Rubey, A. S. Langsdorf, O. J. Ferguson, G. W. Case, F. D. Carvin, C. H. Willis, E. H. Wells, E. J. Streubel, S. C. Hollister, Bro. A. Leo, Louis Mitchell, J. C. Park, W. E. Duckering, G. C. Sagen, W. W. Hartshorn, C. E. Cherry, L. T. Black, F. O. Rose, F. W. Hinrichs, F. B. Lindsay, G. L. Sullivan, A. B. Domonske, E. R. Kiely, R. D. French, A. R. Zimmer, H. S. Evans, G. W. Salzer, E. R. Moore, J. R. Lapham, E. A. Valade, R. L. Sweigert, H. F. Gauss, F. A. Rogers, F. B. Seely, R. E. Rich, Frank Kerekes, I. C. Crawford, W. E. Freeman, L. J. Lassalle, Paul Cloke, C. S. Ell, G. M. Fair, Ralph Earl, C. J. Freund, H. B. Dirks, S. C. Lind, J. B. Butler, W. M. Cobleigh, F. H. Sibley, G. W. Barnwell, H. N. Lendall, M. E. Farris, J. H. Butler, W. W. L. Cowles, J. C. Rathbun, Theo. Baumeister, S. K. Barrett, M. M. Boring, J. J. Devine, B. R. Van Leer, F. E. Ayer, R. S. Burington, LeRoy Tucker, D. M. Palmer, R. H. Dearborn, P. S. Donnell, G. A. Irland, Dawson Dowell, W. N. Jones, R. L. Wales, L. S. LeTellier, R. L. Sumwalt, A. Karsten, W. R. Woolrich, E. H. Flath, H. F. Godeke, W. J. Cope, J. B. Jones, A. R. Drucker, G. B. Boomsliter, F. A. Kartak, W. J. Seeley, E. F. Chandler, H. Schneider, B. H. Bush, J. H. Felgar, B. Stoughton, P. P. Rice, G. E. Crofoot, H. C. Pavian, D. D. Curtis, H. M. Crothers, N. W. Dougherty, L. A. Doggett, N. F. Rode, G. D. Clyde, G. F. Eckhard, W. S. Rodman, E. A. Loew, B. G. Elliott and R. D. Goodrich

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*

COÖPERATIVE EDITING OF TECHNICAL PAPERS

In the search for a method of making technical English strike freshmen and sophomores as more practical, more alive, than it usually appears to such novices, I have been experimenting during the past two years with a project that seems worth a brief summary. It consists of editing an engineering article or report in conjunction with a Technical Writing class.

The first problem is to find a man on the scientific and engineering staffs who consents to coöperate. This has not been difficult. Since 1928 all Michigan Tech. books, monographs, reports, and articles have been edited by myself (or another English department member) in conjunction with the author. The resultant exchange of knowledge and growth of good will have made it easy to get colleagues who will do the editorial job in the classroom rather than the office.

The second problem causes more difficulty. Suitable papers are hard to come by. They ought to be under 2000 words; they cannot—since thus far our Technical Writing has of necessity been restricted to freshmen and sophomores—be too highly technical, but should nevertheless contain a table or so and two or three other sorts of extra-verbal aids; the organization ought to follow rather closely one of the standard patterns for engineering writing; yet the paper should depart from regularity just enough to permit spending say ten or fifteen minutes in class on problems of arrangement and coherence; finally, the papers edited should fit smoothly into the term schedule.

Since perversity rules the world, there always turns out to be a plethora of 5000-word papers written for experts or else several 2000-word articles which are ready for final revision six weeks after the class has finished studying the type of discourse which the article represents. Half a dozen colleagues bring in excellent

technical descriptions during the month when we are enmeshed in recommendation reports.

However, a prod here, a bribe there, and an eagle eye on the production schedule clear up most of these obstacles. The greatest problem remains—the pedagogical procedure to be followed.

Several principles, of course, are obvious. For one thing, the classroom editing must be preceded by an interest-arousing "build-up." I make use of undergraduate, college, and professional engineering journals; of the semi-technical stories and feature articles in the local student newspaper; and, perhaps not too legitimately, of the reports which the English department submits concerning each faculty manuscript that it edits. After the "build-up," and preferably about ten days ahead of the classroom editing, every student is given a mimeographed copy of the article chosen. He is then led to investigate the content, tone, and typographical style ordained by the magazine or institution to which the article will be submitted.

Now the English instructor and Professor Z of the geology or metallurgy or mining or mechanical staff are almost ready for the classroom. To be more nearly exact, they are one or two rehearsals away. I favor two—one before, and one after, the class has asked questions based on its preliminary study of the manuscript, of similar articles, and of the editor and the reader-group aimed at.

The rehearsals are what sink or float the project. In the course of them, English instructor and technical instructor must determine what revisions they will make, and what revisions they will allow, during the classroom session. This matter must not be settled too rigidly. If it is, the smartest fourth of the class will feel bilked. On the other hand, and just as obviously, junior-college students will waste half the hour if left without guidance.

Now the English man and Professor Z are in the classroom. There we can soon take leave of them; for the general principles of a sensible, debunked "socialized recitation" will govern the procedure. A few cautions that apply to the editing project ought, however, to be given:

For freshmen and sophomore classes, a fairly regular alternation of faculty "duolog" and class discussion seems wise.

The editing had best start with a discussion of the problems of organization presented by the paper; but these problems ought to permit a definite, brief solution.

The second stage of editing may well be a checkup on the consistency of the "style"—capitalization, abbreviations, use of numerals, captioning, and the like. In office editing we do this chore along with others or else as our last job. But the first of these

procedures puzzles a good many students and bores more; the second bores all.

Once the "style" has been cleared up, the manuscript should be read aloud, section by section.

During this process, teachers of medium sections had better lay emphasis on securing complete accuracy in diction and phrasing. They should, we have found, avoid paying much attention to the improvement of the sentence structure. Fast sections, though, can help the author and the editor to give sentences a more logical word-order, a more varied syntax, greater emphasis, and (once in a while) euphony and grace.

I have said nothing as yet about changing the content of the paper under consideration. My experience leads me to believe that during the editing procedure a paper which is suitable for classroom revision should undergo few such changes. Questions regarding this matter can be settled in the preliminary discussion of the paper by the English instructor and his students.

It will be seen that the limitations to be put around classroom editing are many. Even more than the absence of pipe or cigarette, these limitations set off classroom editing from office editing. Note that I do not say, "from actual editing." The manuscript that comes out of the classroom ought to be the real thing. It ought to be sent to its destination without further change.

A large order? Yes. Certainly, I for one have never filled it to my own satisfaction or that of my technical colleagues. Nevertheless the results have been encouraging. The project has added to student good will and student knowledge. Freshmen and sophomores realize more fully than otherwise that technical writing—even the minutiæ of technical writing—must receive time and thought. They see that their scientific and engineering instructors write well, should write better, and want to write better. Out of the freshman's head is usually knocked the idea that "composition" is inspiration; out of it is knocked the equally harmful notion that composition consists of revising a 200-word bit until it is flawless and dead. Students work on writings more complex and significant than their own productions, yet not so discouragingly excellent as most specimens in most textbooks, Engineering English textbooks among them. Since the paper being edited is not dismayingly near to perfection, even the freshmen generally suggest many improvements which had escaped the author and me. In fact, we have sometimes felt chagrined at the number of wise emendations that we had overlooked.

The project, then, has paid its way. It would do more if it were conducted better. Eventually, I hope, whatever small taint of artificiality clings to the editing will be removed. Improved

technique should make the rehearsals needless. The project would then accomplish greater results.

Above all, it would do more if senior students and outside engineers could participate. The seniors I have already begun drawing into the web—undergraduates who are preparing papers for local professional groups and for the college newspaper. Junior-college classes on the medium level have edited these men's papers better than they have edited faculty papers. Fast sections have done equally well on both.

Seniors once active, the next step would be to correlate with our classroom editing (and with our more conventional teaching as well) the other three projects in which we have utilized upperclassmen, faculty men, or both. After that, we would seek the outside engineer. We shall probably never get him. Even so, classroom editing appears well worth the time it has taken and the thought it requires.

L. A. Rose,
Associate Professor of English,
Michigan College of Mining and Technology

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

F. M. PORTER, *Editor*, University of Illinois

THE OPPORTUNITY TO INSTILL "ENGINEERING SPIRIT" IN FRESHMEN, AS OFFERED IN THE TEACHING OF ENGINEERING DRAWING*

This discussion is based upon the assumption that we wish to impart constantly throughout the freshman year something of the essence, principles, and ideals of engineering. Of all the courses studied in the first year, drawing and descriptive geometry together offer an introduction to engineering. The student is interested at the outset of a course in which he can use both his hands and his brains. He learns to be neat and accurate in his work. He is made to realize that constructions on the drawing board, as in engineering, must be true in principle and accurate in execution. Throughout the course the authority of truth is being demonstrated both in the lecture room and in the drafting room.

He studies the graphic language and begins to understand drawings which express creations of the mind of an engineer such as he hopes to be. He learns to express himself in this language and appreciates the efficacy of accurate and concise description. He learns that there is a choice of expression in that he may use pictorial methods for the layman, and orthographic drawings for engineers and artisans. If he has selected the latter method, he finds that he must give careful consideration to his description by selecting the best views and arranging them in the most satisfactory manner.

The drawings he makes require planning—thinking through the whole project and visualizing the completed sheet with its various views, dimensions and notes arranged in proper order. This is the type of thinking the engineering mind must be trained to do. Having planned the project, further engineering training is provided in the systematic procedure required for its execution. Finally, when he has completed the drawing neatly, accurately, and with the speed which his skill permits, he feels a pardonable pride of accomplishment.

Throughout an engineering drawing course the student finds that the field of engineering is beginning to open to him through a study of the objects he draws. Although he may not understand how they are designed, he knows that engineering principles are employed and that he will learn to use them to his own satisfaction and profit. His teachers are engineers by training and experience. He feels that he is getting into the profession of engineering. The drawing teacher should take advantage of this favorable attitude of mind and make the most of his opportunity to instill within the student the spirit of engineering.

* Abstract of discussion by C. E. Rowe, Professor of Drawing, The University of Texas, annual meeting of S. P. E. E., College of Texas, June 27, 1938.

INSTITUTIONS INCLUDED IN S. P. E. E. SECTIONS

By GEO. U. CASE

Chairman, University of New Hampshire

Allegheny Section:
Western Pennsylvania—
Geneva College, Beaver Falls
University of Pittsburgh
La Plume Junior College
Carnegie Institute of Technology
Pennsylvania State College
Gettysburg College
West Virginia—
Marshall College, Huntington
State College
West Virginia University

Arkansas-Oklahoma Section:
Arkansas—
University of Arkansas
Oklahoma—
University of Oklahoma
A. & M. College of Oklahoma

Illinois-Indiana Section:
Illinois—
Armour Institute
Lewis Institute
Milliken University
Parks Air College
Northwestern University
Joliet Junior College
Bradley Polytechnic Institute
University of Illinois
Indiana—
Tri-State College
Evansville College
Purdue University
Notre Dame University
Rose Polytechnic Institute
Valparaiso University

Kansas-Nebraska Section:
Kansas—
Kansas State College
University of Kansas
Southwestern College
Nebraska—
University of Nebraska

Kentucky Section:
University of Kentucky
University of Louisville

Middle Atlantic Section:
Eastern Pennsylvania—
Lehigh University
Lafayette College
Haverford College
Bucknell University
Drexel Institute
University of Pennsylvania
International Correspondence School
Swarthmore College
Villanova College
New Jersey—
Princeton University
Stevens Institute
Newark College of Engineering
Rutgers University
Delaware—
University of Delaware
Lower New York State—
Union College
Rensselaer Polytechnic Institute
West Point Military Academy
New York University
Manhattan College
Cooper Union
Fordham University
College of the City of New York

Michigan Section:
University of Michigan
University of Detroit
Wayne University
Detroit Institute of Technology
Michigan State College
General Motors Institute
Grand Rapids Junior College

Missouri Section:
University of Missouri
Missouri School of Mines
Washington University

New England Section:
Maine—
University of Maine
Colby College

New Hampshire—
University of New Hampshire
Dartmouth College
Vermont—
University of Vermont
Norwich University
Massachusetts—
Northeastern University
Wentworth Institute
Massachusetts Institute of Technology
Harvard University
Rindge Technical School
Tufts College
Worcester Polytechnic Institute
Rhode Island—
Rhode Island State College
Brown University
Connecticut—
Trinity College
Yale University
Connecticut State College
Coast Guard Academy, New London

North Midwest Section:
Iowa—
Iowa State College
University of Iowa
Michigan—
College of M. & T., Houghton
Minnesota—
Duluth Junior College
University of Minnesota
Wisconsin—
University of Wisconsin
Marquette University
Oshkosh Teachers College

Ohio Section:
Ohio Northern University
University of Akron
Ohio University
University of Cincinnati
Case School of Applied Science
Fenn College, Cleveland
Ohio State University
University of Dayton
Denison University
Toledo University

Pacific Northwest Section:
Washington—
Washington State College
University of Washington
Oregon—
Oregon Agricultural College
Oregon State College
Idaho—
University of Idaho
Montana—
Montana State College
School of Mines, Butte
Northern Montana College, Havre

Pacific Southwest Section:
California—
Bakersfield Junior College
University of California
Brawley Junior College
Pomona College, Claremont
Fullerton Junior College
Marin Junior College, Kentfield
Long Branch Junior College
University of Southern California
National Schools, Los Angeles
Los Angeles Junior College
Loyola University, Los Angeles
Pasadena Junior College
Institute of Technology, Pasadena
Riverside Junior College
San Bernardino Junior College
School of Mechanic Arts, San Francisco
Cogswell Polytechnic Institute, San Francisco
San Mateo Junior College
Santa Clara University
Santa Rosa Junior College
Stanford University
Taft Junior College
Nevada—
University of Nevada
Utah—
Utah Agricultural College
University of Utah
Arizona—
University of Arizona

Rocky Mountain Section:
Colorado—
University of Colorado
Colorado Agricultural College
Colorado School of Mines
Wyoming—
University of Wyoming
New Mexico—
University of New Mexico
New Mexico State College
New Mexico School of Mines
New Mexico Normal University

South Dakota Section:
South Dakota State College
South Dakota School of Mines
University of South Dakota

Southeastern Section:

Virginia—
Polytechnic Institute, Blacksburg
Military Institute, Lexington
University of Virginia

North Carolina—
University of North Carolina
Duke University
North Carolina State College

South Carolina—
The Citadel, Charleston
Clemson College
University of South Carolina

Georgia—
School of Technology
Boys' H. S.

Florida—
University of Florida
Southern College, Lakeland

Alabama—
Polytechnic Institute
University of Alabama

Mississippi—
State College
University of Mississippi

Louisiana—
State University
Louisiana Institute
Tulane University

Tennessee—
Polytechnic Institute
University of Tennessee
Vanderbilt University

Texas Section:
Texas Agricultural College
University of Texas
Texas A. & M. College
Southern Methodist University
College of Mines, El Paso
Rice Institute
College of Arts & Industries, Kingsville
Technological College, Lubbock

Upper New York Section:
University of Buffalo
Cornell University
Clarkson College of Technology
University of Rochester
Syracuse University

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

At its 1938 annual meeting, held in New York on October 21 and 22, the Engineers' Council for Professional Development elected J. P. H. Perry, of New York, chairman for the coming year. R. E. Doherty, president, Carnegie Institute of Technology, Pittsburgh, Pa., was elected vice-chairman. S. L. Tyler, secretary of the American Institute of Chemical Engineers, New York, takes office as secretary, and C. E. Davies, Secretary of The American Society of Mechanical Engineers, continues as assistant secretary of E. C. P. D.

As chairmen of the four principal committees, the following selections were made: Committee on Student Selection and Guidance, R. L. Sackett; Committee on Engineering Schools, Karl T. Compton; Committee on Professional Training, O. W. Eshbach; and Committee on Professional Recognition, C. F. Scott.

New members of the four committees are the following: Student Selection and Guidance, M. M. Boring and H. O. Croft; Engineering Schools, A. A. Potter (reappointment) and A. B. Newman; Professional Training, E. Warren Bowden and F. L. Eidmann; Professional Recognition, C. F. Scott and D. C. Jackson.

CIVIL ENGINEERING PAGE

Notes of interest for members of the Civil Engineering Division.—Editor, M. W. FURR, *Kansas State, Manhattan*

F. T. MAVIS, *Chairman*
H. C. BIRD, *Past Chairman*
F. W. STUBBS, JR., *Secretary*
M. W. FURR, *Editor*
H. T. HEALD
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PROSPECT OF HYDRAULIC LABORATORY EXPERIMENTS AND RESEARCH 1937–1938

Last year (1938) Committee V, on the subject of Applied Hydraulics, prosecuted a comprehensive program under the Chairmanship of F. T. Mavis, State University of Iowa. The Committee was garnished with subject matter including: (a) Hydraulic Laboratory Experiments for Undergraduate Engineers, (b) Outline of a Typical Report for a Water Power Development, (c) Outline of Work Proposed for the Subsequent Year, (d) How Fluid Should Elementary Hydraulics Be, and (e) A Current Perspective View of Hydraulic Research in Engineering Schools. The foregoing topics were formally discussed by Glen N. Cox, L. S. U.; C. A. Mockmore, O. S. C.; Lorenz G. Straub, U. of Minn.; James G. Woodburn, U. of Wis.; and Kenneth C. Reynolds, M. I. T.; respectively.

It is regretted that sufficient space is not available to review fully this program in this section. However, the editor has planned to complete the review of the program in the December issue, Vol. 4, of the C. E. Bulletin. The Committee has presumed that similar studies, possibly a continuation of the projects mentioned and adding other phases of the subject as desired, will be conducive to those engaged in the 1939 program.

In the report of Kenneth C. Reynolds, a vista of hydraulic research in engineering colleges was presented. The source of the information was from annual bulletins of the National Hydraulic Laboratory entitled "Current Hydraulic Laboratory Research in the United States" and, in addition, from data supplied by committeemen. The 117 research projects of the 24 colleges were classified under the headings of: flow measurements; model tests; flow in channels, pipes, etc.; with a few classified as miscellaneous. About one-quarter of all the projects were in relation to methods of flow measurements such as weirs, dams, meters, orifices, and nozzles. About forty per cent of the work related to model tests; thirty per cent to flow and five per cent to miscellaneous. Moreover, sixty-one per cent of the projects were conducted either as theses or else as laboratory research sponsored by the institution. The remaining projects were conducted for commercial agencies, being federal, state, or private in scope. It was pointed out by Dr. Reynolds that private enterprises may profitably employ the highly trained college staff, who are experimenting day-in and day-out, to make hydraulic investigations to aid in the solution of many of the general problems. The problems of stream bed-load movement, flow over spillway sections, and the

design of silting basins continue to be important in the field of hydraulic research. The report on Hydraulic Research was prepared under the joint effort of Bardsley, Barnes, Harris, Powell, Schoder, Wheaton, and Reynolds.

Glen N. Cox reports that hydraulics laboratory experiments for technical schools for the first course in hydraulics were greatly stimulated by the activities of the E. C. P. D. Also that there was added interest in the work in the hydraulics field due to general interest and certain special studies being made by engineers. A survey on the conduct of laboratory experiments was made by means of a questionnaire. Replies were received from 124 institutions which offered four-year engineering courses, only 108 of the institutions offering work in hydraulic laboratory. It was revealed by the survey that the most common hydraulic experiments with the *per cent* of institutions reporting were offered as follows: orifice, 94; venturi, 91; pipe friction, 82; triangular weir, 82; contracted weir, 79; impulse wheel, 67; gages, 65; pitot tube, 63; nozzle, 56; centrifugal pump, 54; water meter, 51; current meter, 46; suppressed weir, 41; trapezoidal weir, 35; hydraulic ram, 32; reaction turbine, 30; flow through tubes, 16; orifice meter, 10; and sudden contraction, 6. The variation in the number of experiments offered appears to be due to a difference in the time and credit-hours allotted to the course. Since some of the questionnaires included only the work done by students and others included information on all experiments for which equipment was available, the above tabulation over-emphasizes the work assigned to students.

About one-third the number of institutions included in the survey offer graduate work in Hydraulics. The rather wide variation in experiments offered to undergraduates is due to the fact that the work was presented by different departments at the schools from which information was received, the principal requisite for satisfactory work in all cases being *adequate facilities.* Professor Cox determined that where experiments dealing with the flow of oil, air, and steam were in evidence, the work was under the administration of the Petroleum, Chemical, or Mechanical Engineering department. This work was conducted by Benford, Dunstan, Murphy, Wheaton, and sub-chairman Cox.

The outline and discussion of "subject-matter to be considered in water power development," presented by C. A. Mockmore, aroused much interest. It was stated that selection of a site for a proposed water power plant and the preparation of a report to substantiate the decisions of the engineer was rated as an intricate problem. Also, that it is the confession that there are many factors or phases, which relate to the proposed work, that must be thoroughly investigated. The following condensed outline was given to serve in connection with the discussion of the topic: (1) Preliminary Analysis of Site. (2) Hydrology. (3) Water Power Estimates. (4) Dams. (5) Hydraulic and Structural Features. (6) Hydraulic Turbines. (7) Electrical Equipment. (8) Power House Design. (9) Economic Analysis of Development. (10) Comprehensive Report.

Professor Mockmore stated that working-outlines for the various developments of this kind will differ rather widely because of the local conditions. The Lake Chelan development was mentioned as an example, the lake being located on a short stream in the foot-hills of the Cascade Mountains in the state of Washington. The lake is about 45 miles long and 1400 feet deep. The difference of elevation from the mouth of the stream to the outlet from the lake is 415 feet. A development of a power site of this character consisted of a dam at the outlet, a tunnel to conduct the water to the power house, a surge tank, penstock, power house equipment, tailrace, and transmission line. Whereas another development near by on the Columbia River at

Rock Island requires a dam, power house, power house equipment, and transmission system. In college courses in this field there are many things to emphasize, and not the least of the problems are the preliminary studies following a suitable outline. Stream flow records over a long period of time are invaluable to good flow estimates (cf. Article by M. H. Davison, C. E. Bulletin, December, 1938). The questions of multiple use of streams and water rights or what may be termed stream utilization are also of prime importance in the preliminary investigations. The aim is a written comprehensive report to the client and *nothing* should be left out.

The question of which is the *cart* and which is the *horse* is troublesome in prosecuting courses by recitation and laboratory programs. Should the theory of the work be presented to the student before the practical phases or vice versa? This aroused the question of good teaching and Professor Mockmore, Chairman of the sub-committee, concluded his paper on this topic. Professors Morryfield, Lenz, and Camp collaborated in the above report.

(Editor's Note: For the treatment of the remainder of the 1938 Committee V Program refer to the December issue of the C. E. Bulletin.)

ENGINEERING ECONOMY PAGE

Engineering economy specifically relates to the cost aspects of engineering in all phases of the practice of the profession: planning, construction, production, distribution and utilization. Engineering economy in education relates to all the cost aspects of engineering in practice and in addition serves as a threshold through which the engineering student may be directed to an interest in and future participation in the administration and management of industry and civic affairs.

EDMUND D. AYRES, University of Wisconsin, *Editor*

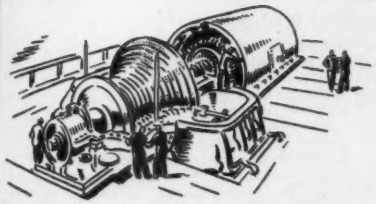
MR. NEWHOUSE COMMENTS FURTHER ON THE REPLACEMENT PROBLEM

(Based on correspondence between Mr. Newhouse and Professor Norton)

I hope that Virginia Polytechnic Institute Bulletin 32 will do much to correct the errors which have heretofore been so prevalent in considering the problem of replacement. I naturally was glad to see that it gave no consideration to the unamortized value of the old equipment in determining whether improved equipment is to be purchased. When the paper was presented in Milwaukee in 1925 containing the A. S. M. E. formulas, I was present at the meeting and was much surprised that I was the only one objecting to including the unamortized value of present equipment. I think I might have hesitated to make my small contribution to the discussion if I had not recalled that during the World War Allis-Chalmers designed and built a machine for turning the copper bands on 3″ shrapnel casings and high explosive shells which replaced twenty lathes and twenty operators. As this machine operated continuously and was of rather inexpensive design due to the fact that it was not so heavy as an ordinary lathe, it completely paid for itself in actual labor savings effected in less than three months. As it operated for more than two years, it was obvious that no manufacturer under such circumstances could afford not to build such a machine whether or not he scrapped the twenty lathes. If other universities will give the same correct reasoning to such subjects, it is my opinion that courses in engineering economy should be included in the various engineering curricula. I know that Professor Ayres, at least for many years, has believed that from a true economic standpoint no consideration should be given to the unamortized value of existing equipment. I believe that the problem on page 726 of the June issue of the JOURNAL OF ENGINEERING EDUCATION was presented in order to cause further discussion of this subject.

R. C. NEWHOUSE, Chief Engineer,
Crushing & Cement Machinery Division,
Allis-Chalmers Manufacturing Company.

G-E Campus News



100,000 HORSEPOWER

AN 80,000-kilowatt turbine-generator, using steam at a pressure of 1250 pounds per square inch and at 900 F in a single cylinder to generate 100,000 horsepower, is being built at General Electric's Schenectady Works.

The latest results of constant research and experiment by G-E turbine engineers are embodied in this new unit. It will be the first large 1200-pound condensing unit built in a single casing; the generator will be hydrogen-cooled to reduce windage losses; special alloys are being used to meet high pressures and temperatures.

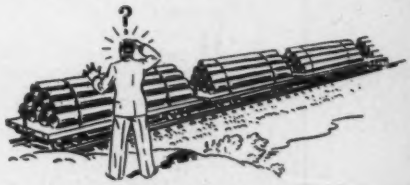
The gigantic boiler is as large as a 9-story building 36 feet wide and 54 feet deep. Steam will shoot from it into the turbine at a pressure of 1250 pounds per square inch. One twentieth of a second later the steam will be cool water, the effect of the amazing change being to drive the unit's rotor at 1800 revolutions a minute.

Soon the foremen will report—"work completed." Tests will begin, calling into action student engineers—recent graduates of engineering schools and colleges. Then, an estimated 14 months after work began, the turbine will be shipped from Schenectady.

FROM MODERNISTIC CABINETS TO 36-INCH STEEL PIPE

WHEN inspectors of the City of Los Angeles Water Department were confronted by 13,000 feet of steel pipe waiting for their inspection, they were dismayed. For inspection meant checking every square foot of the pipe to see that the layers of enamel were of a specified thickness on both the inner and the outer surfaces.

It meant the tedious task of stripping and micrometering samples of the pipe at random, the accepted but not infallible method.



On a search for a better way went one of the inspectors. He found a magazine article about General Electric's electromagnetic thickness gages being used to measure, without marring, the thickness of the enamel coating on refrigerator cabinets. The aesthetic difference between a modernistic cabinet and a steel pipe didn't bother the inspector—he simply bridged the gap with his imagination.

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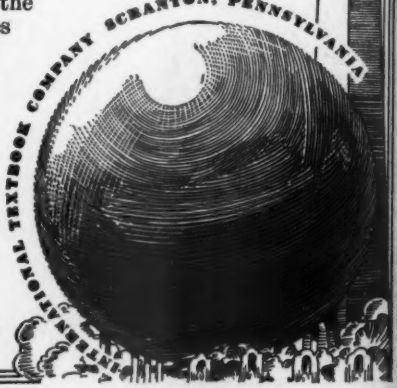
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